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## SOME OBSERVATIONS ON PHYTOPATHOLOGICAL PROBLEMS IN EUROPE AND AMERICA[1]

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In order to understand and appreciate present phytopathological conditions and problems, a brief reference to the development of the scientific study of plant diseases may be appropriate. Plant pathology, unlike animal pathology, is an almost new subject of investigation. Germany, in this as in most scientific work, took the lead. Kühn[2] in 1858 published the first distinct treatise on plant diseases worthy of mention. Then followed the work of De Bary and Pasteur, who laid the mycological and bacteriological foundations for scientific work in plant pathology, or parasitology, which includes the major portion of the subject at present. Next came the work of Frank, Sorauer, and Kirchner in Germany; Prillieux, Cornu, and Millardet in France; and Berkeley, Plowright and Ward in England. In America, the pioneers, Burrill, Farlow, and Bessey, were beginning work along this line in the seventies. The present epoch in the development of American phytopathology dates from the establishment of the Section of Vegetable Pathology of the Department of Agriculture in 1886, twenty-seven years ago, and the work of Scribner, Galloway, and Smith. Few branches of science have made such wonderful progress in a quarter of a century.

In the early days the workers were few and scattered, and each was busy with his special problems, the solution of which has made possible the broader outlook and rapid advance of the past decade. The recent great development of science, pure and applied, throughout the civilized world, and the easier and more frequent communication between nations has brought about much closer personal, agricultural and general commercial

[1] Read before the American Phytopathological Society, Cleveland, Ohio, January 2, 1913. This was the second of three papers in the Symposium on International Aspects of Phytopathological Problems. The first of these by L. R. Jones on The Importance of Closer International Relations in Phytopathology, will soon be published in Science; the third by W. A. Orton on International Phytopathological Problems connected with Quarantine Legislation will appear in a later number of PHYTOPATHOLOGY.

[2] Julius Kühn. Die Krankheiten der Kulturgewächse, ihre Ursachen und ihre Verhütung. Berlin, 1858; 2nd unaltered edition 1859.

relations, and thus new phytopathological problems have been created as well as greater importance given to old ones. Plant parasites and diseases have no respect for political boundaries. The constant and increasing interchange of cultivated plants and their products between different countires has naturally resulted in many cases in greatly facilitating the distribution and spread of serious plant parasites into countries and localities where they were formerly unknown. Some of the most conspicuous and well known instances of the introduction of new pests are to be found among the insects, such as the San Jose scale, the codling moth, and the gypsy moth. There are, however, conspicuous cases of plant parasites also, as downy mildew of potato, asparagus rust, etc.

The United States, as the foremost nation at present engaged in the collection, study and dissemination of useful plants, and as a leader in research in phytopathology, is under peculiar obligations to increase our knowledge of plant diseases and to do all in her power to prevent their spread. The attention of the general public has only lately been forcibly called to this subject. The recent introduction of the white pine blister rust, the potato wart disease, and perhaps also the chestnut blight fungus, has served at least one good purpose by arousing the public somewhat in regard to the seriousness of the situation. The sooner we get a broader and more comprehensive view and knowledge of these matters and the various important problems involved, the better it will be for all concerned.

During the past season the writer had an opportunity to continue and extend his previous pathological studies and observations more carefully in the fields and laboratories of Europe, and also to discuss the subjects with various foreign pathologists and horticulturists. Our observations began at Naples, Italy, from which point we worked north through Italy, Switzerland, Germany, Holland, Denmark and Sweden, and also England and Scotland. Attention was devoted particularly to fruit diseases and their causal organisms, with a view to determining the identity, or otherwise, of American and European diseases and parasites, and also their relations, distribution and destructiveness.

The study at home of foreign literature and specimens cannot give one a satisfactory knowledge of pathological conditions in Europe or other foreign countries. Actual observation soon convinced me that we have no adequate conception of the situation and problems. This is not generally due to any particular fault on the part of foreign plant pathologists in describing their diseases and organisms, but to our lack of an exact knowledge of the various environmental, cultural and other conditions which must be understood and considered.

In order to bring out some of the most striking and important facts and questions involved it may be best to discuss some specific cases studied.

The diseases to be considered fall chiefly into two groups: (1) those severe in Europe, but less so in America; (2) those severe in America, but not so in Europe.

### DISEASES SEVERE IN EUROPE, BUT LESS SO IN AMERICA

Some of the most striking cases in the first group are the brown rots of fruits, Sclerotinia (Monilia) diseases. In America these diseases appear to be confined mostly, so far as their economic importance is concerned, to the stone fruits, peaches, plums and cherries, attacking chiefly the fruit, but sometimes also the blossoms and twigs, especially in case of the peach and plum. Brown rot has been observed in this country but rarely on pomaceous fruits, as the apple, pear and quince. We were much surprised, therefore, to find in northern Europe, especially in Denmark and Holland, that the brown rot behaved in a quite different manner from anything observed in this country. We found the sour cherry trees, which had been infected through the blossoms, with the twigs and branches so seriously killed back that the trees had somewhat the appearance of pear trees suffering from a bad case of blight. We were told that this was a common occurrence. We also found that apples, pears and quinces were frequently attacked by brown rot, especially the fruit. Old Sclerotinia mummies of apples and pears were frequently found in most orchards. The blossoms and twigs were also attacked, but not so seriously as in the case of cherries, plums and peaches. At Zürich Dr. Schellenberg exhibited specimens of quince twigs which had been killed back from six inches to a foot by Monilia, and we were told that this was not an uncommon occurrence.

European pathologists have expressed the opinion that there are several species of Sclerotinia which attack fruit trees in Europe. Whether there are sufficient morphological differences to justify the specific separation of the organisms may be questioned. There is no doubt, however, about the great difference in the behavior of the brown rots in Europe and America. Since Sclerotinia occurs, occasionally at least, in America, on practically all the fruits mentioned, and is not restricted entirely to particular hosts, the European and American organisms would not seem to be separable on a host basis. The conspicuous differences are in the virility and behavior of the organisms in the two countries. Why these differences occur can only be determined by a very thorough study of all the factors involved in the problem. We are of the opinion that different climatic conditions may have much to do with the differences in behavior of these parasites, and it may be found that the species, variety or race which is so virulent on cherries, for example, in Europe does not occur in this country.

As already mentioned, our purpose in this paper is to point out some of the important international pathological problems which have impressed

us most. We are not prepared at present to offer any final solution for most of them and will only give such suggestions as have been derived from a general study of the questions. We hope to contribute something further toward the solution of some of these specific problems when we have had fuller opportunity to study the material and data collected.

Next to the brown rots, the Nectria canker of apple, pear and quince, which has been attributed to *Nectria ditissima* Tul., proved most interesting and remarkable. This Nectria canker of apples is said to have been observed in a few localities in America, e.g., North Carolina, New York, Canada, New Hampshire, and recently it has been reported from northern California; but it is more of a rarity at present than a disease of economic importance. The first cases of this disease we observed were in northern Italy and southern Switzerland, where the trees were in such a neglected and debilitated condition that they would have been an easy prey to almost any fungus. Farther north, however, in Germany, Holland and Denmark, we found an abundance of evidence that this fungus is a very serious menace to apple trees; in fact, certain varieties such as Red Astrachan and Cox's Orange Pippin are so badly injured by this canker that some growers have abandoned their cultivation. Even where careful attention had been given to cultivation, pruning, spraying, and the general treatment of orchards, these varieties especially were very badly injured. If the disease which has been attributed to *Nectria ditissima* in this country, is really caused by the European fungus the difference in its behavior in Europe and America is remarkable. It is more probable that the American fungus has been incorrectly identified. Doctor Seaver, who has recently studied the species of Nectria, expresses the opinion that the *Nectria ditissima* of American mycologists is the same as *Nectria coccinea* (Pers.). European mycologists have also recently stated that the fungus causing the apple canker in Europe has been incorrectly identified and is not *Nectria ditissima* Tul. but *N. galligena* Bres., a fungus which has not been reported from this country. It seems probable, therefore, that the true European Nectria canker does not occur here. If so, every possible precaution should be taken to prevent its introduction, as we have at present no canker disease in America which approaches it in destructiveness.

The silver leaf disease of plums and apples has recently attracted much attention in Europe and has been reported from America. Professor Brooks, of Cambridge, England, seems to have demonstrated beyond question that *Stereum purpureum* is able to produce this disease, but whether a similar effect may be produced by some other organism or cause is not known at present. Certain varieties of plums, such as Victoria, are particularly subject to this disease and are very seriously affected by it.

We had an opportunity to go over Professor Brooks' inoculation experi-

ments with him and there seems no way of escaping his conclusions. He admits, of course, that there may be other causes producing similar effects. Since *Stereum purpureum* is generally regarded by mycologists as a cosmopolitan species, and is found in most parts of the United States, the question arises why the disease attributed to it is not more frequently met with in other countries.

Again, the powdery mildew of strawberries is a rather serious disease in northern Europe, especially in England, whereas the same fungus supposedly occurs in this country upon the strawberry, but very rarely produces any serious injury.

The diseases thus far mentioned and the organisms producing them have been generally regarded as endemic in both Europe and America, and the differences in behavior in the two countries can not, therefore, be accounted for in the way usual with introduced diseases.

The powdery mildews of oak and of gooseberry, which have recently overrun Europe and are generally believed to have been introduced from America, are also very interesting and furnish excellent material for phytopathological study. Unfortunately, however, the history of their introduction and spread is not clearly established. The oak mildew has recently been described as a new species. Its appearance in Europe, however, is very similar to that of our common oak mildew in this country, which is regarded by some mycologists as identical with the mildew growing in Europe on certain other hosts. The fact that it rarely produces perithecia in Europe also suggests its foreign origin, as the powdery mildew of grapes, which is generally considered of American origin, behaves in the same manner. The existence of races and strains of the powdery mildews showing different degrees of parasitism on the same host, as well as on different hosts, has been shown by Salmon and Ward.

The difference in the behavior of the gooseberry mildew in Europe and America seems to be due largely to the European host being a much more susceptible plant than our American gooseberry, though climatic conditions are also, perhaps, involved. The same may be true of the oak mildew.

The black rot of grape, which is generally regarded as introduced in Europe, seems to affect the European varieties more seriously than the American under the same conditions, and this difference in susceptibility of species and varieties of hosts appears to be the primary cause of the difference in the severity of the disease.

### DISEASES SEVERE IN AMERICA, BUT NOT SO IN EUROPE

We may now discuss briefly the second group of diseases, those which are serious and important in America but not so in Europe. The black rot of apple is a conspicuous example of this class. The fungus, *Sphaeropsis*

*malorum*, which causes the trouble, has been found in various parts of Europe, from Italy to England, though it is apparently not common and has sometimes passed under other names, as *Diplodia pseudodiplodia* Fckl. The fungus has been found on apple twigs and also on apples, the type specimens having been collected in England and described by Berkeley. The difference in the behavior of the organism in the two cases is, however, very remarkable. As is well known, the black rot of apple in America is a widespread and destructive disease, attacking fruit, foliage and branches, while in Europe it has never been reported as doing any noticeable injury in orchards. Here of course physiological races or strains of the organism, or possibly mistaken identity, may be involved.

What has been said of the black rot of apple is also apparently equally true of the bitter rot caused by *Glomerella cingulata* (Stonem.) S. & v. S. The conidial stage of this fungus, *Gloeosporium fructigenum*, was first found and described by Berkeley in England and has since been found in most other European countries. It has never been known to do any particular injury to apples there, whereas, in certain regions and seasons in America it is one of our worst apple diseases. There seems to be no doubt of the morphological identity of the organism in both countries and the striking difference in its behavior still remains to be explained. The work of Schneider-Orelli seems to indicate that there are physiological differences between certain American and European forms especially as to optimum temperature for growth.

The behavior of asparagus rust is also interesting. There seems to be no doubt of its introduction from Europe with its host. It does not usually cause serious trouble in Europe but is very destructive in this country. In this case climatic conditions seem to be clearly of primary importance. The higher night temperature in summer in this country, with accompanying dews, seems to favor the spread of infection by uredospores. Asparagus rust, in common with some other rusts, furnishes one of the comparatively few cases among fungus parasites in which other parasites may play a noticeable part in its control. *Tuberculina persicina* and *Darluca filum* are both well known parasites of rusts, and in this case the latter may be of benefit in destroying the rust. I fear, however, we can hardly hope to demonstrate at present that such parasites are of sufficient importance to justify large appropriations for their introduction and dissemination.

When visiting Dr. Ferraris, the Italian pathologist at Alba, I was much interested in cultures and specimens of pear blight which he exhibited. The specimens were collected in Italy, but thus far the disease has attracted little or no attention, possibly on account of its recent introduction. In view of the rapidity with which this disease spreads when once established

in any locality in America, it will be interesting to watch its behavior in Europe. Dr. Ferraris seemed to have no doubt of the disease being due to *Bacillus amylovorus*, and his specimens of affected twigs certainly had the appearance of being killed by pear blight.

Many other examples of the difference in behavior of the same organisms in different countries and different regions might be cited from other fields of biology, such as the cases of introduced flowering plants, which in some instances rapidly overrun the country and become serious weed pests, while in their native homes they assume no such importance.

I was particularly struck with the fact, which is of course familiar to entomologists, that the codling moth, while a native of Europe, does not cause any very serious harm there. We were told by one of the largest apple growers in England that he did not find it necessary to spray or combat in any way the codling moth, as the amount of injury to the fruit was usually a negligible quantity. Parasites and other natural enemies of the insect are usually considered responsible for holding it in check in its native haunts, I believe. Whether this has been satisfactorily demonstrated or not I do not know. It seems probable that climatic conditions are also involved.

The all-important question which arises in connection with the diseases and organisms we have mentioned is, What are the specific controlling causes of the phenomena? Mention may be made of some of what appear to me to be the most probable and important factors concerned. First, perhaps, are differences in climate or other environmental conditions. Further investigations along this line, we believe, will throw some light upon these problems, and a careful study of this phase of the question should give profitable results. Americans, I think, do not usually appreciate the climatic differences between Europe and America. I doubt, for instance, whether most of us think of Naples as in practically the same latitude as New York City. The regions north of Italy differ chiefly in climatic conditions from those in the northern United States in their lower average summer temperatures and higher average winter temperatures. There are also, of course, great differences in the average and seasonal rainfalls and in general humidity. Closer co-operation between weather bureaus and meteorological observatories, and greater attention to the collection and publication of data, with special reference to botanical and pathological problems, would be of great assistance in throwing light upon some of these questions.

Another factor which is no doubt an important one in accounting for some cases is the existence of different varieties, races, or strains of a host plant, which even under the same conditions, show different degrees of susceptibility to the same disease. This is generally believed to account

for certain of the cases mentioned, especially the greater virulence of powdery mildew on European gooseberries than on American varieties, as it is found that the European varieties when grown in this country are also very seriously attacked by the disease. The behavior of our black rot and powdery mildew of grapes in Europe appears to be explained in the same way. Whether the chestnut blight is another case of this kind remains to be determined.

Studies in recent years have also apparently established the fact that there exist different varieties, races, or strains of parasitic fungi which show different degrees of virility or ability to produce disease, even under the same conditions and on the same hosts. These differences are usually of a physiological character and have not generally been coördinated with any distinctive morphological peculiarities. Whether the existence of these races or strains is the cause of some of the phenomena noted has not yet been satisfactorily determined, but a thorough investigation of this phase of the subject should be made by testing the European strains by carefully controlled inoculation experiments under American conditions.

Another explanation of some cases is probably to be found in a mistaken identification of the organisms involved, as was suggested in connection with the apple canker fungus, *Nectria ditissima*. This emphasizes the great necessity of a very thorough comparative study, both morphologically and physiologically, of the disease producing organisms of the different countries. This knowledge is of fundamental importance.

What has already been said seems sufficient to indicate something of the number and importance of the international problems confronting us and some of the chief lines of scientific investigation which should be vigorously pursued. This brings us to the question of our duties and privileges as a nation and as phytopathologists. Phytopathological problems are no longer local problems, but world problems, and the sooner we recognize and adopt this point of view, the sooner we shall be able to successfully attack them.

The present public interest in these matters, as indicated by legislation in regard to inspection and quarantine recently adopted in various countries, and especially the law lately enacted in this country, shows some appreciation of the dangers which threaten agriculture and horticulture from the spread of plant diseases and pests. From the standpoint of the pathologist, however, the chief attention at present should be given to a more thorough study and investigation of the fundamental scientific problems of pathology involved, as it is only by an understanding of these that measures of prevention and control can be practically and profitably devised. If the money which has been spent in attempts to eradicate diseases after they have been introduced into a country could have been spent

in thorough scientific investigation of the diseases and organisms and their methods of dissemination and means of prevention, much more satisfactory results could have been accomplished. These problems can only be studied to advantage by thoroughly trained pathologists with a broad knowledge of American conditions and diseases and adequate facilities for comparative field and laboratory studies in foreign countries. Such studies would greatly increase our knowledge of phytopathology and would furnish a sound basis for the formulation and enforcement of inspection and quarantine laws. No satisfactory laws or quarantine and inspection measures relating to fungus parasites can be adopted or satisfactorily enforced until our knowledge of these problems and conditions is greatly increased.

It does not necessarily follow that a disease which is virulent in Europe or some other foreign country will be equally serious or more so when introduced into this country, though we are of course amply justified in quarantining against such diseases. On the other hand, it is not safe to assume that a parasite which is of little or no economic importance in another country will not prove a serious parasite when introduced into this country. A great need at present is to discover some safe basis for predicting what the behavior of the parasite will be when introduced into any new locality. This might perhaps be done by making careful inoculation experiments with the foreign organism in this country under thoroughly controlled conditions, so that there is no danger of its spreading.

The inspection of seeds, plants, or nursery stock of any kind, as a means of detecting the presence of many of their fungus parasites, is almost useless, as it is well established that many of these organisms live in the tissues of the host or beneath bud scales, or in other protected places where their detection is practically impossible, and disinfection or destruction equally impossible, without destroying the host plant. In the case of insect pests detection and fumigation are of course much more effective. Since fungous parasites cannot be detected by inspection with any degree of certainty, and it is impracticable to quarantine against everything which may be dangerous, some other means must be found to prevent the dissemination of foreign fungous diseases. This we believe would be accomplished in the most effective manner by the plan which has been proposed of establishing quarantine stations where imported plants suspected of harboring parasites shall be grown under the observation of pathologists for at least one year before they are distributed. This provision we believe should be added to the present law. Attempts to eradicate parasites when once introduced have thus far been expensive and futile. An ounce of prevention in this case is worth many pounds of cure.

Let us consider briefly the chief existing agencies which may be utilized in extending and advancing international phytopathology and assisting

in the solution of the many problems, both scientific and economic, which confront us. The problems connected with inspection and quarantine, and legislative and administrative action for the prevention of the introduction and further dissemination of dangerous parasites can be most satisfactorily attacked by the closest co-operation between the departments and officials in the different countries and states having charge of the inspection of plants and the enforcement of laws relating thereto. The Consular Service might be utilized to some extent, perhaps, in this connection also. A careful, comparative study of the laws, regulations and methods employed in other countries might also be helpful.

The advancement of our knowledge of the scientific phases of phytopathology and the solution of its most pressing international problems can be promoted through various existing agencies, some of which have been already incidentally mentioned. We may call attention to the following: First, The International Institute of Agriculture at Rome, which has a Bureau of Agricultural Intelligence and Plant Diseases. This Institute was established and ratified by forty-eight governments and is supposed to have their active support and co-operation. It possesses great possibilities if properly supported financially and officially and conducted by a sufficient staff of competent pathologists. At present the bureau referred to issues a monthly bulletin devoting a small space to abstracts or reviews of current pathological literature, and occasionally containing a report from some government pathologist. The usefulness of this bureau could be greatly increased if it were possible to arrange, through the co-operation of all the governments concerned, to prepare and publish promptly abstracts, or mention at least, of all the phytopathological literature of the world, a thing which is not accomplished at present by any publication. There are a dozen or more publications giving partial lists of current pathological papers, but none is complete. One is compelled to look over most of these lists if he would keep in touch with the latest results of investigation in this field of research, but he can never feel reasonably certain that some important paper has not been missed. This would be an important step in the general conservation movement, also, as the dissipation of time, money and energy by all concerned is enormous, and the final results at present unsatis factory.

Another agency which is not sufficiently developed or utilized at present is the Centralstelle für Pilzkulturen, conducted by Miss Johanna Westerdijk, Amsterdam, Holland, in connection with the International Association of Botanists and the Willie Commelin Scholten. The purpose of the work is to make available through purchase or exchange pure cultures of fungi, especially those which are pathogenic.

The interchange of professors of pathology with foreign countries would also bring about a better understanding of international conditions and problems, as well as of the pathologists themselves, and would tend to bring us into more intimate and sympathetic relations with each other.

The proposal to have foreign pathologists visit this country, study pathological conditions and give us the benefit of their European experience is an excellent one and certain to prove mutually beneficial. The organization of an international phytopathological society might also be a valuable means of securing more united effort and cooperation in the solution of our problems.

The appearance and rapid spread of the chestnut blight, as well as other diseases which have recently appeared in this country, have called forcibly to our attention the importance and necessity of securing more accurate information in regard to the origin, history and spread of pathogenic fungi and the conditions and factors involved in epidemics.

To summarize, then, we believe that the various facts cited demonstrate beyond question the necessity of a broader pathological outlook. Most phytopathological problems in ultimate analysis are international and to be most successfully attacked must be approached from that standpoint. Their solution can be most quickly and economically accomplished by close and active cooperation between the different governments and pathologists. Investigators should have the fullest facilities for observation and research wherever the problem leads, without reference to political boundaries.

The solution of the fundamental problems already discussed must, in great measure, precede the establishment of the most efficient means and methods for preventing or restricting the dissemination of pathogenic fungi.

# THE USE OF THE GREEN MUSCARDINE IN THE CONTROL OF SOME SUGAR CANE PESTS

JAMES BIRCH RORER

WITH PLATE VII

The most serious problem which has confronted the scientific workers in the West Indies for the past five or six years is the control of the so-called blight of sugar cane in Trinidad, which is caused by the froghopper, *Tomaspis varia*, one of the Cercopidæ. The insect in its nymphal stage lives under ground and kills the roots of the cane by sucking, so that the plants stop growing, and, if subsequent weather conditions are unfavorable, gradually dry up and become a total loss, or, if the rains are plentiful, make a fresh start, but never recover the lost ground either in weight or in purity of juice. Up to the present no egg parasite or other active enemies of the froghopper have been found.[1] A predaceous bug has recently been imported from Mexico but it will take it many years to increase sufficiently under the most favorable conditions, so as to act as a successful means of control.

Another cane pest of considerable importance is the small moth borer, *Diatraea saccharalis* and allied species, which, though held in check to a considerable extent by natural insect enemies, still does a great amount of damage.

Yet a third type of pest in some of the Leeward Islands and Porto Rico consists of the larvæ of beetles belonging to the genus Lachnosterna.

Curiously enough all these insects belonging to widely different families are very susceptible to the green muscardine, an epizootic disease caused by the fungus *Metarrhizium anisopliæ* Sorokin, in consequence of which a study of this fungus, with special reference to the froghoppers, was undertaken. In a paper entitled The Green Muscardine of Froghopper, published in 1910,[2] the writer has already discussed the nomenclature of the fungus and its history in Trinidad, and has also given results of inoculation experiments in both the laboratory and the field, which prove conclusively that it is a very active and destructive parasite of the froghopper in the adult and nymphal stages.

[1] Since this paper was prepared an hymenopterous egg parasite has been found in Trinidad.

[2] Rorer, J. B. The greeen muscardine of froghoppers. Proceed. Agric. Soc. Trinidad and Tobago **10**: 467–482. 1 plate. 1910.

More recent observations have shown that female froghoppers when once infected die before oviposition—a point of great practical value—while the larvæ of the moth borer and Lachnosterna beetles, when dusted with spores, succumb to the disease within a few days. When used as a means of control for any of these pests, especially the froghopper, spores are required in large quantities and much time has been devoted during the past six months to perfecting the method of growing the fungus in the culture cabinets first described in the paper already indicated.

About twenty-five cabinets are now in use on various estates and give very good results if properly cared for. The unit cabinet is a box approximately 3 feet square and 6 feet high lined with galvanized iron, with a steam pipe running down through the center, and containing a number of galvanized shelves. About 3 inches above each shelf, on either one of the sides or the back, it is immaterial which, two holes $\frac{1}{2}$ inch in diameter are made through to the outside and fitted with galvanized tubes $1\frac{1}{2}$ inches long which are soldered to the galvanized lining and plugged with corks on the outside. The cabinets are inoculated through these tubes. The central steam pipe is soldered to the lining at top and bottom and has six or eight very small perforations, not more than $\frac{1}{16}$ to $\frac{1}{32}$ inch in diameter to allow steam to enter the cabinet. A valve must be placed on the lower end of the pipe outside the cabinet to allow condensation water to escape, while the water which collects within the cabinet itself can be drawn off through a small tube placed in the bottom. The door is grooved to match a tongue on the cabinet and the groove is partly filled with cotton, which has been soaked in a solution of mercuric chloride and dried, making a tight, antiseptic joint. It is necessary to have several glass panels in the door, since the fungus seems to produce spores more quickly in light than in darkness. The glass is protected with sheets of asbestos during sterilization. The door is fastened in place by bolts (plate VII, figs. 1, 2, and 3).

The cabinet or series of cabinets should be located in as clean a place as possible; a specially built room is preferable, but is not necessary. Live steam for sterilizing is essential. In crop time on a cane estate this may be had from the large boilers, but out of crop there is generally a small boiler in use to run the engine for curing sugar, or for the workshop, from which steam may be obtained; 30 to 40 pounds pressure is all that is needed.

The method of operating a cabinet is as follows: About 40 pounds of rice is thoroughly washed and boiled for ten to fifteen minutes, either in a kettle over a fire, or, better and more quickly, by allowing live steam to escape from perforated cross pipes in the bottom of a pot or half-barrel in which the rice, with the required amount of water, has been placed. The cooked rice should be drained dry and while still hot spread in a layer about $\frac{1}{4}$ inch thick over all the shelves in the cabinet. The door is then

immediately put in place and steam turned on. A thermometer in a cork may be inserted in one of the inoculating holes and a temperature of 100°C. maintained for an hour. This sterilization is repeated on three or four successive days, care being taken that the steam valve is tightly closed after each heating, so that the cabinet will cool down thoroughly. It is then ready for inoculation.

Spores in sufficient quantities for inoculating cabinets can be readily obtained. At the beginning single spores should be cut out from petri dish cultures and transplanted to potato cylinders made and sterilized in the ordinary way except that no water is added to the tubes, so that the medium will be fairly dry. The fungus spreads very slowly at first but soon produces spores in the central part of the growth. In order to hasten the culture these spores may be spread all over the surface of the potato cylinder with a sterile needle. They will soon germinate and within two weeks a moderately thick crust of spores will be found over the whole cylinder. Spore crusts from about ten to fifteen cultures are loosened with a sterile platinum loop or needle and turned out into a sterile tube, which is then plugged with sterile cotton.

For inoculating purposes a 50 cc. Erlenmeyer flask, which has been previously sterilized in a hot oven, is used. The flask is fitted with a cork and glass tubes somewhat after the fashion of a chemical laboratory wash bottle, except that the outer end of the discharge tube is not drawn to a point and the inner end is just flush with the bottom of the cork. The spores are emptied into this flask. An atomizer bulb with a piece of sterile cotton tied over the intake valve is attached to one tube while the other is inserted in turn into each of the holes in the cabinet and a charge of spores blown in quickly by a slight pressure of the bulb. If the inoculating is thoroughly done as soon as the cabinet has cooled down after the last sterilization, the whole surface of the rice should be covered with the white felt-like mycelium of the fungus within three or four days, and spore production will be at its maximum (in tropical temperatures) after two or three weeks. The cabinet is then ready for opening. As the shelves are taken out they are dusted over thickly with cassava starch or flour and the whole mixture is gradually brushed off the tray with a moderately stiff brush, such as a scrubbing brush, or better, a white wash brush with the bristles cut off to about half length, on to a rectangular sieve about three feet long and $1\frac{1}{2}$ feet wide. By shaking or stirring with a brush the starch and spore mixture will pass through the sieve and after a little more dilution with starch or flour is ready for use, while the residual rice can also be kept for spreading about the cane fields. A cabinet with ten shelves about 3 feet square should give at least 70 pounds of the spore and starch mixture, while there will be about one-third of a barrel of rice.

Although many cabinets give absolutely pure cultures of the green muscardine fungus it is not advisable to use spores from this source for inoculating other cabinets, since impurities from the air, especially if the cabinets are located near a sugar mill, are almost sure to get in, and will quickly overrun the rice before the right fungus gets its foothold. In Trinidad the writer supplies all the planters who have cabinets with pure spores for inoculating purposes. The spores are obtained from potato cylinders, as already described, and in part from cultures made in petri dishes. A flour and water mixture is made just thin enough to pour. About a dessert spoonful is put into each of a number of petri dishes which are tilted in all ways till the bottoms are covered. These are sterilized in an autoclave at 110°C. for ten minutes, or in a steamer on four successive days. They are inoculated by slightly raising the cover and blowing in spores from the flask inoculator already described. Potato cylinders or other media in tubes can also be inoculated by means of this blower. With a boy to remove and replace the plugs one can quite easily inoculate one hundred tubes in ten minutes, and if the work is done in a culture room there need be no fear of impurities. The writer has made over fifteen hundred tubes this year without a single foreign organism getting in.

Spores will be formed on the flour paste in about two weeks, and can be brushed off with a small sterile brush into a clean sterile petri dish and transferred later to sterile cotton-plugged tubes. The flour petri dishes will continue to produce "ratoon" crops of spores for two or three weeks, and if the successive productions are taken off in a clean culture room there need be no fear of contamination. One such culture will give enough spores to inoculate several cabinets.

Many different ways of using the fungus in the field have been tried and two have proved successful this year in starting epidemics of the disease. The first may be called hand infection, and works well where the infested area is more or less limited in extent. A number of boys with tubes containing spore-bearing cultures walk through the cane fields and wherever they see a froghopper resting on a leaf they catch him in the tube and then let him jump out again. Ten or twelve boys can cover a fairly large area in a day. The infected insects soon die and within a week or ten days the fungus is fruiting on their bodies so that they become a source of infection for others. In this way the fungus has been well established on one or two of the small estates.

Spreading the spores with dusting machines is the method which has given most success in the treatment of large areas, and this is essential in dealing with the froghopper. Machines of the Kansas City "Cyclone" type have been used with good results and the "Furet," a French apparatus, is also well adapted for the purpose. The spores should be applied at the

rate of 2 or 3 pounds to the acre so that the product from one culture in a cabinet should cover from 20 to 25 acres.

The first field treated this year (1912) was one of 20 acres on Orange Grove estate. The dusting was done during the first week in August, and actual counts in this field made by Mr. Urich, Entomologist of the Board of Agriculture, six weeks later showed an average of 92 dead insects per cane stool or about 184,000 per acre, and infection was still going on.

During the coming season every effort will be made to start an epidemic as early as possible after the rains begin, with the hope that the first brood of froghoppers may be kept down to the minimum.

BOARD OF AGRICULTURE
PORT-OF-SPAIN, TRINIDAD, B.W.I.

EXPLANATION OF PLATE VII

FIG. 1. Cabinet closed ready for sterilization. This cabinet contains ten shelves.

FIG. 2. Cabinet opened with shelves removed. The inoculating holes are in the back. The cock at base of steam pipe allows condensation water to escape.

FIG. 3. Cabinet opened showing rice covered with pure growth of green muscardine. In this cabinet the steam pipes run along the sides and are joined under each shelf by a cross pipe. This arrangement has no advantage over the central pipe and is more expensive.

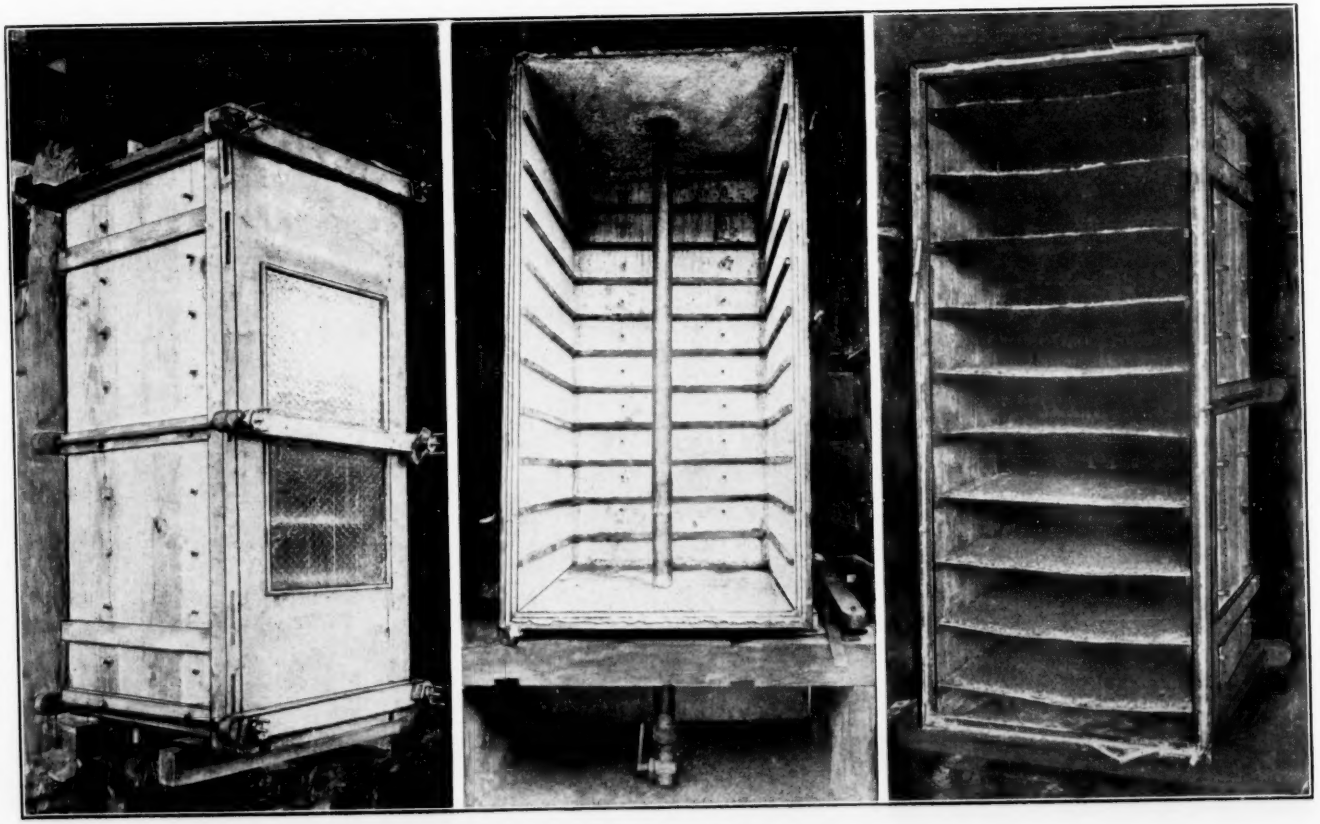


PLATE VII. CULTURE CHAMBERS

# THE STEM ROT OR HAWAIIAN "ILIAU" DISEASE OF SUGAR CANE

C. W. Edgerton

With Plate VIII

During the past two years there has been under observation in Louisiana a serious disease of sugar cane caused by a fungus of the genus Gnomonia. The disease was first noticed in West Baton Rouge Parish in the summer of 1910 but has since been seen in other parishes in the central and northern parts of the state. The general appearance of the disease resembles in a way that caused by the root rot fungus, *Marasmius plicatus,* and it is possible that the two have been confused in the past. Until recently it was thought that this disease was new and perhaps confined to this country, but there has appeared a bulletin[1] from the Hawaiian Sugar Planters' Association which either describes the disease or one very similar to it. In this bulletin, the causative fungus is described as a new species, *Gnomonia iliau.* While the Hawaiian fungus as described by Lyon differs slightly from the Louisiana material as will be mentioned later, it is probable that the two are the same and the latter will, at least for the present, be considered as *Gnomonia iliau.*

The disease does considerable damage in the state, especially in the northern portion of the sugar cane belt. It does not seem to cause as much injury in the southern part of the state where the most of the cane is grown, though from reports of sugar planters it probably occurs in that region. This agrees with Lyon's statement concerning the disease in Hawaii as he says that the disease is only severe in the cooler regions of the islands, or during a cool season when the cane is not able to survive the attack.

The fungus attacks the cane in all its earlier stages of growth and then remains upon it during the rest of the season. It more frequently attacks the stalks in the spring before they begin to joint. If the cane is attacked early and the season is favorable to the disease many of the stalks remain small and often die, and many of those that live will not reach a height of more than one to two feet during the summer. If the attack is not so severe or the season is more favorable to the cane, the stalks joint and attempt to outgrow the disease. Some of these stalks will live through the season,

[1] Lyon, H. L. Iliau, an endemic cane disease. Hawaiian Sugar Planters' Association, Pathological and Physiological Series, Bulletin 11. 1912.

and though they are generally small, will be cut at grinding time, while others will finally succumb. The rot in the lower joints causes the stalks to weaken and finally they break off near the surface of the ground and fall over.

If the small stalks are examined, it will be found that all of the leaf sheaths near the ground are firmly cemented together by the fungus mycelium. The sheaths are dead and also the blades of all of the lower leaves. A few green leaves will be seen protruding above the dead mass of leaf sheaths at the base. If the sheaths are pulled apart a dense layer of white mycelium will be seen between them (fig. 3). The fungus often fruits on these small stalks, though perhaps not so abundantly as on the larger ones.

On jointed stalks that are diseased the lower leaf sheaths are cemented closely to the stalk and the white mycelium is abundant between them, as well as within the tissues (figs. 1 and 2). Many of the blades of the lower leaves are dead and the living leaves at the top often have a yellowish appearance and are close together, forming a loose tuft. The lower joints of a diseased stalk, underneath the dead leaf sheaths, are shorter than normal ones and also are often much less in diameter than the joints above the diseased portion. The mycelium not only attacks the leaf sheaths but also enteres the rind tissue so that often the sheaths are quite firmly cemented to the stalk itself. The fungus gradually works through the rind and in towards the center of the stalk, though the progress inward is not rapid. The tissue is turned to a red color as the disease passes towards the center. If a diseased stalk is cut across one sees on the outside the layer of dried and shrunken leaf sheaths, then the dead and slightly discolored rind tissue, then a ring of red parenchyma tissue, and finally on the inside a cylinder of uncolored, perfectly healthy parenchyma tissue. The killing of the rind tissue weakens the stalks and many of them fall or are blown over by the wind.

As can be seen, this disease resembles the root rot disease in that the leaf sheaths are firmly cemented together with the white mycelium. However, the latter disease does not pass into the rind tissue, and in this way it can be readily distinguished. Furthermore, the leaf sheaths do not pull apart as readily when they are attacked by the Gnomonia as they do when affected with the Marasmius, and also there is the lack of the mycelial strands which are often present with the root rot disease. In the Gnomonia disease there is a whitish to grayish mat of mycelium both within the tissues of the leaf sheaths as well as between them, while with the root rot the mycelium is seen mostly between the leaf sheaths. The sheaths are more severely rotted by the Gnomonia, the mycelium taking the place of the leaf tissue.

The Gnomonia fruits abundantly on the dead leaf sheaths, especially towards the fall of the year on the larger jointed stalks. Two stages of the fungus are present, the imperfect, which perhaps belongs to the form genus Melanconium, and the ascogenous, the latter being the more abundant. In the late summer or fall, nearly every stalk affected with the disease will be seen to be covered with the perithecia. This differs from the condition described by Lyon in the Hawaiian Islands. He states that the perithecial stage is not often seen and was not found until after the disease had been studied for some time. In Louisiana the perithecia were the first to attract attention, and it has always been easy to find them, while the Melanconium stage has not been so abundant. In fact, until some conidial pustules developed in cultures this stage was not known. Since then, however, a few of them have often been found on stalks in the field and many have been seen on inoculated plants in the greenhouse (fig. 2) and on inoculated stalks in moist chambers.

The imperfect stage (fig. 2) either develops in the outer leaf sheaths or in the more deeply covered ones. One can pull off the outer ones and see the small pustules that have developed and forced their spores out between the sheaths. Lyon states that this stage belongs to the form genus Melanconium and describes it under the name, *Melanconium iliau*. It may be as well to consider it as a Melanconium, although the fruiting pustules are not typical of this genus. Instead of the spores being borne in open pustules or acervuli they are usually in well developed pycnidia as shown in figure 4. These pycnidia are imbedded in the leaf tissue, generally with but a pore at the top, though occasionally the apex may be prolonged into a well developed beak. While most of them are quite regular in shape, being more or less subglobose, rather irregular pycnidia are frequently seen. There are often iregularities in the conidiophore-bearing tissue in the shape of protuberances or flaps which extend up into the pycnidial cavity, these sometimes producing almost a chambered condition. At the time the pycnidia develop the leaf is so badly decayed that they are more imbedded in the fungus tissue than in the leaf tissue (fig. 4). They are usually about 500–700$\mu$ in diameter and quite thin walled. The spores, which are borne singly on the conidiophores, are very dark brown in color, elliptical to oval, coarsely granular, 7–10 x 15–28$\mu$. If they develop in a moist place they ooze out of the pycnidia in inky-black, slimy strings (fig. 2), but if they develop in a dryer place they merely form a smutty covering over the leaf sheath.

The perithecia develop very abundantly over the surface of the exposed dead leaf sheaths and give the stalks a very characteristic appearance (fig. 1). The beaks extend for some distance from the surface and are very hard; in fact when the finger is drawn over the surface of the stalk it is

like drawing it over a sharp file. The perithecia (fig. 5) are perfectly typical of the genus Gnomonia, about 325–480 x 240–340$\mu$ in size, and with a beak about 350–550$\mu$ long. The asci are clavate, thin walled, 60–80 x 8–14$\mu$, and have a well developed pore at the apex. The spores are divided into two equal cells, hyaline, generally slightly curved, often slightly constricted at the septum, 22–30 x 5–7$\mu$.

In describing the Hawaiian material, Lyon says the asci are 55–60 x 8–12$\mu$, the ascospores 20–25 x 3–5$\mu$, and the spores of the imperfect stage 15–22 x 6–8$\mu$, these all being slightly less than the corresponding measurements of the Louisiana fungus. Specimens have been received from Dr. Lyon and examined and there seems to be no doubt but that there is a small difference in the measurements of the fungi as they occur in the two countries. The larger size of the spores and asci, and also the fact that the perithecia develop very abundantly in Louisiana and only occasionally in the Hawaiian Islands, seem to be the only differences between the fungus as it occurs in this country and in Hawaii. On account of the similarity of the two in other respects, it seems very doubtful if these are real differences.

The fungus has been cultured a number of times from the conidia and ascospores and also by making direct transfers from the diseased tissues. It grows readily in pure cultures, producing a dense white mycelium. The conidia develop on special media such as oat juice agar, but the perithecia seem to require the host plant for their development.

A number of inoculation experiments have been tried during the past two years in order to prove that the fungus was the cause of the disease. Mycelium from pure cultures, or spores direct from diseased cane, have been inoculated into healthy stalks both in the greenhouse and in the field. When young plants were used a good development of the disease always followed, but when large, jointed stalks were inoculated the disease was not produced. It would seem that the fungus must be firmly established in the leaf sheath tissue before it can attack the rind tissue of the stalks.

While studying the disease it seemed very probable that much of the trouble in the field came from planting infected seed stalks. In order to prove this diseased stalks, and also healthy stalks which had the spores of the fungus sprayed upon them, were planted in pots in the greenhouse. In practically every case the young plants that grew from these stalks were badly diseased. In most cases the young plants died after they reached a height of from 2 to 12 inches. An examination of these dead plants always showed the leaf sheaths to be firmly cemented together with the fungus mycelium, similar to the plants found in the field.

In a previous paragraph attention was called to the fact that the disease seems to do more damage in the northern part of the state than it does in the southern and it may be well to explain the probable reason for this.

Lyon states that in the Hawaiian Islands the disease is naturally more severe in the cooler regions, and this may be one of the factors in Louisiana, but it is not the only one, and probably not the one of most importance. The real cause seems to be in the methods of saving and planting cane as practiced by the farmers in the different sections. In the northern part of the state the planters put their cane down in beds during the winter to keep it from freezing. Since there are many stalks in contact, disease present on any of them has an excellent opportunity to spread to others in the bed, and by planting time many of the stalks have the fungus in various stages of development. These stalks, when planted, naturally produce diseased plants. In the southern part of the state, where the most of the cane is grown, the farmers either plant directly in the field in the fall or else windrow the cane until spring. With either of these methods there are not many stalks in contact and there is but slight chance for the disease to spread from stalk to stalk, and where these are used the sugar cane is not severely damaged by the disease.

LOUISIANA AGRICULTURAL EXPERIMENT STATION
BATON ROUGE, LOUISIANA

## EXPLANATION OF PLATE VIII

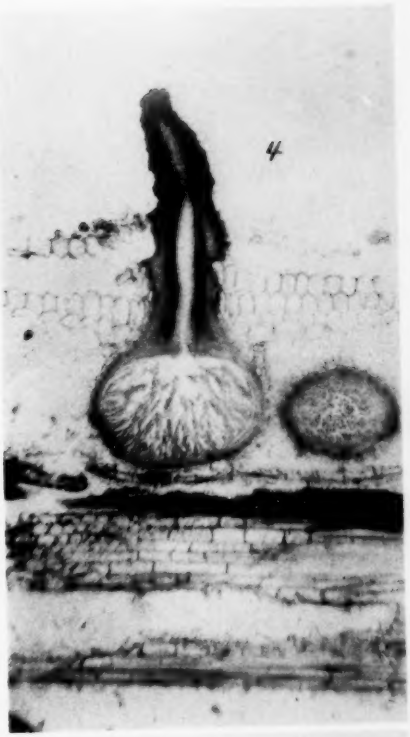
FIG. 1. A large stalk of sugar cane affected with Gnomonia iliau, showing the leaf sheaths still surrounding the stalk and the abundance of perithecia of the fungus.

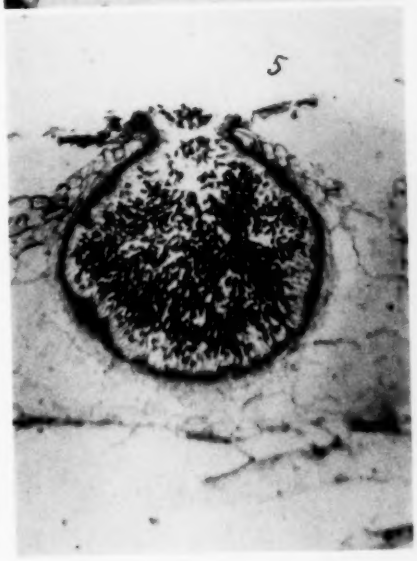
FIG. 2. A stalk of cane affected with Gnomonia iliau, following inoculation with pure culture, showing the pustules of the imperfect stage of the fungus.

FIG. 3. A stalk of cane badly affected with the disease. The outer leaf sheaths have been stripped off and the white mycelium of the fungus is visible.

FIG. 4. Photomicrograph of perithecium of Gnomonia iliau. × 67.

FIG. 5. Photomicrograph of the imperfect stage of Gnomonia iliau. × 67.






GNOMONIA ILIAU

PLATE VIII STEM ROT OF SUGAR CANE

EXECUTED BY THE WYANOAK PUBLISHING COMPANY, NEW YORK

# JONATHAN FRUIT SPOT

J. B. S. Norton

It may be of interest to those who are working with this recently described[1] disease of apples to know that the same condition can be practically duplicated by the action of certain gases. It was noticed last autumn that apples and pears fumigated with small amounts of formaldehyde developed under the lenticels the small black spots which characterize the Jonathan spot. Several varieties of apple and Keiffer pears were then placed under bell jars and a few drops of ammonia or formaldehyde added in watch glasses, with suitable checks of a similar nature without the ammonia or formaldehyde. Although no very extensive investigations were carried out, it was found that one drop of ammonia to about four liters of space would produce the spots over night.

The spots appear light brown at first, and in some varieties remain so for a long time and are often inconspicuous. In red varieties (Arkansas Black and Jonathan), the black color develops in a day or two after the injury. It also comes out quickly in pears, giving very dark spots in a few hours. If the fruits are kept in a moist atmosphere pitting does not take place soon, but when calcium chloride is kept under the jars, the spots soon appear sunken.

Some varieties seem much more sensitive to the action of the gases, the Jonathan proving particularly so as compared with the several other varieties tried. In these experimental apples, as well as those of spotted Spitzenburg and Jonathan taken from storage in Washington, there is nearly always a distinctly unaffected area around the calyx. Some badly pitted apples taken from cold storage had a very conspicuous ammonia-like odor in their paper wrapping, which suggested the idea that ammonia from the cooling apparatus might be a common cause of the Jonathan spot. While inquiry among men familiar with cold storage work revealed a number of cases where ammonia leaks had caused fruit-spotting, it is not probable that any great amount of damage is done in this way, since, with the usual modern methods of cold storage, there is little opportunity for ammo-

[1] Scott, W. M. Phytopathology **1**: 32–34. 1911. Scott, W. M. and Roberts, J. W. U. S. Dept. Agr. Bur. Pl. Ind. Circ. 112. 1913. Mentioned also by Beach and Clark, N. Y. Agr. Exp. Sta. Bul. 248: 300. 1904.

nia to reach the fruit, and also it is well known that the spot may appear on the fruit while yet on the tree.

A somewhat similar effect of sulfur fumes on Spitzenburg apples has been reported.[2]

MARYLAND AGRICULTURAL EXPERIMENT STATION
COLLEGE PARK, MARYLAND

[2] Eustace, H. J. N. Y. (Geneva) Agr. Exp. Sta. Bul. 297: 135. 1908.

# SOME OBSERVATIONS ON POLYPORUS BERKELEYI

JAMES R. WEIR

WITH PLATE IX

Numerous references are found in the literature regarding the proximity of *Polyporus berkeleyi* Fr. to the base of trees, either in contact with, or between the large spurs of the roots, or in connection with buried wood of some sort.

In the east the tree is said to be usually an oak and the writer has collected it under oaks in the Carolinas. That the oak association may change to one of beech in Indiana and larch in Idaho certainly shows a much wider range for this fungus, in two ways, than heretofore reported. The peculiar and highly interesting affinity the fungus exhibits for particular species of trees in different sections of the United States is not always easy to explain. Probably the wide-spreading crown and buttressed roots of the oak and beech furnish a more favorable protection for the best growth of the fungus than some other forest trees. The depth and quality of the forest mold, through which a portion of the mycelium always ramifies, even if the fungus is attached to a woody substratum, may be greater and the moisture content more uniform. Certainly, the thickness of the mold and the constant moisture conditions surrounding the root system of certain forest trees are some of the main reasons for their selection by this fungus. Such conditions would materially aid any saprophytic or parasitic tendencies a root fungus might possess by promoting an increased vegetative activity.

During the past summer the writer has made extensive collections of *Polyporus berkeleyi* in the forests of Montana and Idaho, where it is very common, always occurring at the base of larches; and in point of size it frequently rivals any of the dimensions so far given in the literature. Its constant association with the western larch (*Larix occidentalis*) is of interest inasmuch as numerous observations show the fungus to have the ability to spread its mycelium as a wound fungus in the wood of the root spurs which have been weakened or opened up by fire or through the attack of pine squirrels or some burrowing animals which frequent the thick deposits at the base of the trees. The depth and extent of this débris about the roots of old larch trees is favorable for, and affords much protection to, the vigorous mycelium always produced by this fungus. The deposit, consisting of the materials of the outer bark and the annual leaf fall, which usually,

owing to the narrow crown of the larch, collects at the base of the tree, forms a mound of considerable thickness, often two or three feet deep. Moisture collects in this material to such an extent that it is not easily destroyed by surface or ground fires and the fungus continues to spring from a perennial mycelium year after year and the materials become matted about the roots in one compact mass.

The sporophores usually spring from the deepest-buried root spurs and in order to bring the pileus into the open a long stipe or "root" is developed, the length depending upon the depth of the mound about the tree. Figure 1 shows a sporophore with a stipe some 10 inches in length which was directly attached to an area of diseased wood extending longitudinally along the root spur and continuing into the living wood above in finger-like streaks. Sporophores may appear some distance away from the base of the tree but the felted mat of mycelium can be traced deep into the mound about the roots and will be found to be in connection with some of the smaller lateral roots of the main spurs (fig. 2). These smaller roots are frequently entirely diseased and the mycelium of the fungus is found ramifying throughout the decayed wood (fig. 4) from which it is possible to grow a sporophore when the wood is buried in the forest mold in a part of the forest from which the fungus has not been collected. The decayed wood from both smaller and larger roots exhibits a stringy white appearance, the primary cell wall materials remaining intact longest. In the early stages of the decay the annual rings separate, owing to the greater activity of the mycelium in the spring wood.

There is no evidence forthcoming that the mycelium has the ability to attack living wood. But on the contrary, it appears to extend into and decay wood of trees killed by fire in early life. Since wounding the peripheral wood causes extensive areas in the longitudinal axis of the root to become dead or functionless, the mycelium of the fungus invades these regions and eventually brings about the white rot already indicated and becomes more or less permanently established, both in the wood and in the deposits about the base, as the tree increases in age. The sporophores are larger and greater in number the older the tree becomes.

It will be noted in the illustration that the stipe is very irregular in contour. This is partly due to the obstruction it has encountered in the mass of materials through which it has passed, also, to a natural lateral regeneration induced by contact with moist woody substances in the mound about the tree. It has been determined that the mycelium composing the basal part of the stipe or "root" remains active after the sporophore dies and that it may be the source of a new sporophore the following year, or, in case of its premature destruction, it may regenerate another the same year (fig. 3).

*Polyporus berkeleyi* has always been of interest to the mycologist, owing to its large size—the largest of the stiped polypores in the United States—and its echinulate spores. Its common occurrence throughout the forests of northern Idaho and its evident saprophytism on the roots of the western larch seem of sufficient interest here to merit this short account.

OFFICE OF INVESTIGATIONS IN FOREST PATHOLOGY
U. S. DEPARTMENT OF AGRICULTURE
MISSOULA, MONTANA

EXPLANATION OF PLATE IX

Fig. 1. Sporophore showing long root-like extension of the stipe. The mycelium supporting this sporophore extended throughout the dead wood of a wound of a living root spur of *Larix occidentalis*.

Fig. 2. Sporophore from a small root of the main spur, *Larix occidentalis*. A portion of the root was still living. The mycelium had extended a distance of 2 or 3 feet in each direction.

Fig. 3. Basal section of a stipe or "root" 15 inches long regenerating a small sporophore.

Fig. 4. Longitudinal sections of roots of *Larix occidentalis* decayed through the action of the mycelium of *P. berkeleyi*. The black lines show extent of mycelium in the wood.

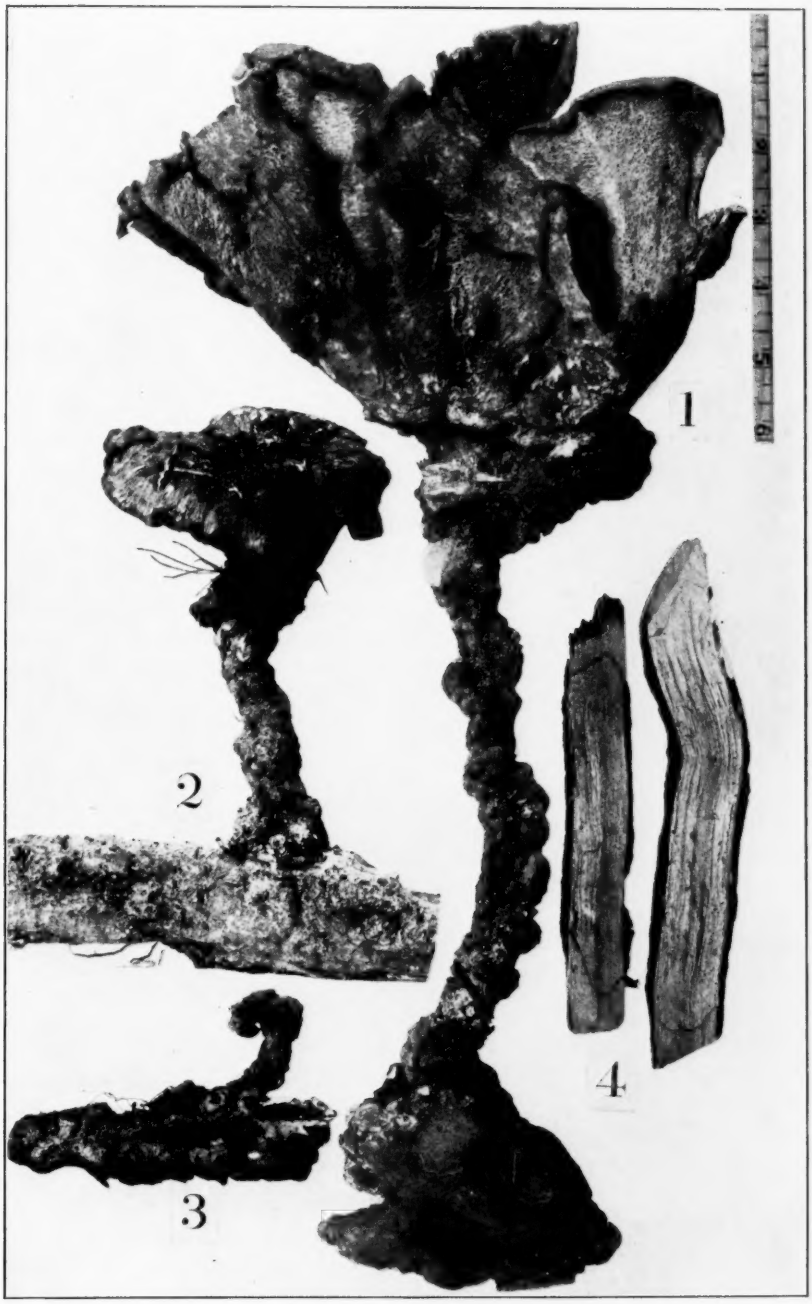



PLATE IX POLYPORUS BERKELEYI

# THE BROWN ROT CANKER OF THE PEACH

R. A. Jehle

With Plate X

During the summer of 1911 and 1912 the writer investigated a canker which was prevalent in Niagara County, New York. A large number of peach orchards within a radius of about ten miles of Newfane were visited and many cankers were found in some of them, while in others there were relatively few. In one orchard, containing about two thousand trees, almost every tree had from twenty-five to fifty cankers (plate X, fig. 1), and none of the orchards visited were absolutely free. The varieties chiefly grown in that region are Elberta, Early Crawford, Late Crawford, and Early St. John. All seem to be very susceptible to the disease, but the Elberta appears to suffer more than the other varieties.

Cankers were found on limbs of all sizes, from those of the second year's growth to those of the larger main limbs, but they were most prevalent on limbs about one to two inches in diameter. The first symptoms of the canker are a sinking of the tissue just beneath the bark, followed by the formation of a gum pocket in this sunken area. Later, the bark cracks and splits and the gum oozes out as a sticky mass. A callus is soon formed outside of the diseased area and sometimes the wound heals over, but usually this callus becomes diseased. The following year healing is again attempted and the callus usually is again invaded. This process is repeated year after year so that several such calli are formed. The writer has seen as many as five on a single canker. In many of these cankers, by removing the bark, discolored areas can be seen extending into the healthy tissue at the upper and lower extremities. The cankers are always much longer than broad, but in many cases the branch is completely or almost girdled and the portion of the branch beyond the canker is killed.

In all of these cankers fruit spurs or branches are to be found, and to some of these were still clinging mummified peaches which had been attacked by the brown rot fungus, *Sclerotinia cinerea* (Bon.) Schroet. When this point was noted it suggested that these cankers might be caused by this fungus, it having gained entrance to the wood through the fruit spur and spread out in the bark when it reached the large limb, thus producing the canker. It seems to be the very general opinion among European workers that the brown rot fungus of America is *Sclerotinia cinerea*. The writer

has under observation cultures of *Sclerotinia cinerea* and *Sclerotinia fructigena* from Europe with which several of our American forms are being compared. At present he is of the opinion that our common form, usually called *Sclerotinia fructigena*, is really *Sclerotinia cinerea*, although further study is required to reach a satisfactory conclusion. In any case the organism mentioned in this paper is the common brown rot fungus of the peach and plum as it occurs in eastern United States. The discolored tissue in the cankers was examined and mycelium found in abundance. In one of the mounts made from a canker collected on May 4, 1911, conidial chains were found which were identical in every respect with those characteristically produced by the fungus, *Sclerotinia cinerea*, and on May 27 similar chains were found in another canker.

On June 7 poured plate cultures of potato agar were made from wood of cankers obtained from various places. The cankers were first sterilized by burning alcohol on the surface, then strips of diseased wood were cut out just under the bark with a sterile scalpel. These pieces were planted in poured plates of potato agar and within twenty-four hours ash-gray conidia were produced all over the wood. Microscopic examination showed them to be identical in size, shape and manner of growth with those produced by the fungus on peach mummies. Some of these conidia were transferred to slant tubes of potato agar and within a few days pure cultures of *Sclerotinia cinerea* were secured. During the summer of 1911 and 1912 similar results were repeatedly obtained.

On May 13, 1911 six brown rot peach mummies were tied to peach limbs and moistened several times daily in order to keep a film of moisture between the mummy and the bark. These were examined on May 26 and one had become fastened to the limb, to which it was tied, with a gummy substance. When the mummy was removed the limb showed the characteristic symptoms of brown rot canker, the fungus having apparently entered the limb through a slight injury in the bark. Pieces of bark were removed from three twigs with a sterile scalpel, and peach brown rot mummies were tied to the wood where the bark had been removed. When these were examined they were all found to be gumming heavily and showed distinct symptoms of the disease. Similar results were obtained repeatedly during the remainder of the summer. Plate **X**, figure 2, shows a canker produced in this manner. The mummy was tied to the peach limb in June, 1911, and the limb was collected and photographed in December, 1912.

On June 24 peach twigs were inoculated with conidia and pieces of mycelium from pure cultures of *Sclerotinia cinerea*. The most successful results were obtained when pieces of the mycelium were placed in contact with the cambium layer, then wrapping the wounds with paper. The checks were treated in exactly the same manner, except that no mycelium was placed in contact with the cambium layer. This method was employed in all of the

following inoculations. On June 23 five peach twigs were inoculated and five others were left as checks. When these were examined on June 28 infection had taken place in every wound which had been inoculated; and on some of them the characteristic ash-gray conidia of the fungus were being produced in large numbers, accompanied by oozing of gum about the wound, while in the checks there was only slight or no gumming and no evidence of infection. July 20, 21 and 22 ninety-five more limbs were treated in the same manner and inoculated, while ninety-five others were left as checks, thus making a total of one hundred inoculations and one hundred checks. These were all examined on August 5 and on all of the inoculated limbs typical brown rot cankers were being produced, accompanied by the oozing of a great abundance of gum from the wounds, while those twigs and branches which were merely cut and not inoculated were healing over, with little or no gumming. During the summer of 1912 similar inoculations were made using strains of the fungus obtained from various sources with the same results.

When the cankers produced by inoculation in 1911 were examined in the spring of 1912, and again in December, 1912, none of them showed any signs of healing over, while the checks had almost entirely healed. Plate X, figure 3, is a photograph of one of these inoculations as it appeared in December, 1912, and figure 4 is a photograph of a check as it appeared at the same time. Figure 5 is the photograph of a canker produced naturally. Four of these cankers produced by inoculation in 1911 were removed from the trees and brought into the laboratory, and on May 23 poured plate cultures were made from small pieces of wood taken just beneath the bark at the junction of diseased and healthy wood. When these were examined on June 1 mycelium had grown from these pieces of wood out on to the agar on the plates, and the typical ash-gray brown rot conidia were being produced. Transfers of these brown rot conidia were made to slant tubes of potato agar, and within a few days pure cultures of *Sclerotinia cinerea* were obtained. Thus, the fungus had remained alive in the cankers during the winter and only needed favorable conditions to call it forth into activity. Limbs of all sizes were used in these experiments, from the previous year's growth to the large main limbs of the tree, and infection took place readily in all cases. Some inoculations were made on current year's growth with the result that the fungus killed it outright, producing twig infection identical with that produced in nature.

A careful study of the peach orchards in the vicinity of Newfane revealed the fact that the fungus enters the limbs of the peach trees in two distinct ways, namely, through the diseased blossoms and through the diseased fruits. During the spring of 1911 and 1912 blossom infection was found to be very prevalent in the peach orchards around Olcott, Burt, and Newfane. It was especially abundant in orchards where brown rot apothecia were

produced in large numbers. Blossom infection was carefully studied during the spring of 1911 and 1912 and infection seemed to begin at the calyx or shuck and spread from there into the stamens and pistil, accompanied by a withering and browning of the diseased portion. Sometimes only the shuck becomes diseased and this is then shed without further injury to the pistil, but usually the entire flower becomes infected and the disease travels down the pedicel of the peach flower, finally entering the fruit spur, causing there the exudation of a large quantity of gum, which surrounds the blossom and seals it fast to the spur. Such diseased blossoms remain clinging to the fruit spurs during the entire summer, and whenever there is sufficient moisture the typical ash-gray conidia are produced in great abundance on the infected floral parts or fruit spur, and are a source of infection for healthy fruit. Where the fruit spurs are borne on large peach limbs the fungus may travel down the spur into the large limb where it spreads out and produces a canker. When the spur is produced on a small limb, that limb is killed outright and typical twig blight is produced. The fungus may continue this killing process until a large limb is finally reached and then may spread out and form a canker. Sometimes the fungus travels slowly, and only a small area surrounding the fruit spur becomes infected.

During the summers of 1911 and 1912 there was very little brown rot on the peach fruit in the Niagara district. What little did occur was found when the fruit was ripening. The brown rot on the fruit was carefully studied, and in almost every case it was observed that the disease passed into the fruit spur and from there gained entrance into the limb which bore the fruit. Sometimes cankers were eventually produced, while in other cases the disease progressed a short distance and apparently produced no further injury. On July 5, 1911, five peaches were inoculated with Sclerotinia spores by stabbing the fruit with a sterile needle, and introducing the spores. When these were examined on July 12, it was found that the fungus had entered the fruit spur in every case. Thus the fungus may enter the spur within seven days after the fruit becomes infected with brown rot.

The control of the canker disease may be undertaken along the three following lines: control of blossom infection, control of fruit infection, and by surgical methods.

For blossom infection self-boiled lime sulphur (8–8–50), concentrated lime-sulphur (1–40), and dusting with sulphur were tried. The applications were made just before the blossoms opened. Where the self-boiled lime-sulphur and dry sulphur were used, just as much blossom infection was found on the sprayed and dusted trees as on the untreated trees, but very little was found on the tree sprayed with concentrated lime-sulphur, and absolutely no injury to the blossoms or leaves resulted from the application.

Spraying for the control of brown rot on the fruit was attempted in several peach orchards during the summer of 1911 and 1912, using self-boiled lime-

sulphur (8–8–50), atomic sulphur (5–50), and sulphur in suspension (5–50), in all cases following the directions of W. M. Scott (7) in his bulletin on the Control of Peach Brown Rot and Scab. Very little brown rot occurred in the district during that time. Consequently, no results were obtained from most of these experiments. Where the disease was present, brown rot infection on the fruit was reduced from 10 per cent on the check trees to 1 per cent on the sprayed trees, all materials giving equally good results.

Many cankers in the vicinity of Burt and Newfane were cleaned and treated during the summer of 1911. In cleaning out the cankers all of the diseased wood was removed, the wound pointed at the upper and lower extremities, and the cambium and bark cut at right angles to the wood. The cankers were treated with a disinfectant (usually corrosive sublimate, 1–1000) and coated with gas tar. These treated cankers were frequently examined during the summer of 1912 and they were all observed to be healing nicely.

Except for the mention of this disease by Dr. Güssow (5) in his last report, the writer has never found brown rot reported as causing cankers on large peach limbs. It has been reported by Salmon (6) as producing a canker on apples in England. He asserts that the fungus enters the limbs directly from mummified fruits, and that conidia may be produced over the cankered area, breaking out through cracks in the bark from the underlying mycelium. F. A. Waugh (12) describes a canker on plum trees which he attributes to the brown rot and plum pocket fungi. His opinion is that the fungus starts the cankers by killing the fruit spur, which induces gumming, thus preventing the healing of the wound. The disease has been frequently reported as attacking the twigs of the peach, cherry, apple, and plum. Erwin F. Smith (8) records it as attacking peach twigs in the Delaware and Chesapeake peninsula. Card and Sprague (2) report that in 1901 and 1902 the diseases attacked the twigs of the sand cherry in Rhode Island.

Sorauer (9) is of the opinion that the fungus can attack the fruit and twigs more easily if they have first been wounded by frost or in other ways. Chester (3) notes it on peach twigs in Delaware in 1892, and Bailey (1) in New York in 1894. Taft (10) finds it on plum twigs in Michigan in 1894. Woronin (13) reports the brown rot fungi, of which he considers that there are two distinct species, *Sclerotinia cinerea* and *S. fructigena*, as attacking twigs of the cherry and apple in Russia. W. M. Scott (7) says: "The fungus also attacks the twigs, thus often destroying a portion of the fruit crops at blossoming time. The diseased blossoms turn brown and become dried, adhering to the twigs for some weeks. The fungus may extend from the dead blossoms into the bark, forming a small brown canker which frequently girdles the twig." Goff (4) reports the disease as attacking the native plums in Wisconsin, and E. Voges states that *Sclerotinia fructigena*

and *Sclerotinia cinerea* attack apple and cherry twigs in Germany. Dr. Shear, at the Cleveland meeting of the American Phytopathological Society, reports it as exceedingly destructive, and as producing large cankers on cherries, plums, and apples in Europe.

The writer wishes to acknowledge his indebtedness to Dr. D. Reddick for numerous helpful criticisms and suggestions.

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EXPLANATION OF PLATE X

FIG. 1. A peach orchard near Burt, N. Y severely infested with brown rot canker. There were from twenty-five to fifty cankers on almost every tree.

FIG. 2. A brown rot canker produced on a peach limb by removing a piece of bark with a sterile scalpel and tying a peach mummy to the exposed portion.

FIG. 3. A brown rot canker produced on a peach limb by removing a piece of bark with a sterile scalpel and introducing spores and mycelium from pure cultures of Sclerotinia cinerea just beneath the cambium.

FIG. 4. A peach limb treated in exactly the same manner, except that no spores or mycelium were introduced into the wound. Note that the wound has almost completely healed over.

FIG. 5. A peach limb upon which a brown rot canker has been naturally produced. Note the fruit spur through which the fungus entered the limb from a diseased fruit.

PLATE X BROWN ROT CANKER OF PEACH

# NOTES ON SOME DISEASES OF TREES IN OUR NATIONAL FORESTS. III[1]

GEORGE GRANT HEDGCOCK

The present paper is a continuation of observational notes[2] on forest diseases, made chiefly by the writer during August, September and October, 1912.

## WOOD-ROTTING DISEASES OF FOREST TREES

*Polyporus dryophilus* Berk., or a closely related species, is the cause of a disease of the heartwood of the aspen (*Populus tremuloides*) in some portions of Colorado. Like *Fomes applanatus* (Pers.) Wallr, it is associated with *Fomes igniarius* (L.) Gillet. It attacks the trunk of the trees chiefly, entering the heartwood either through fire scars or in the base of dead limbs after they are broken off, and causes a heart rot of a yellowish color, interspersed with strands of brown mycelia near the region where the sporophores originate. The trees die either by breaking off, or in some cases, from the direct effect of the fungus, which, when the disease becomes far advanced, attacks the sapwood, producing a white rot. This in the aspen is not a piped rot, such as is caused by *P. dryophilus* in species of oaks. The difference in the texture of the rotten wood in the aspen as compared with that in the oaks can hardly be ascribed to a difference in the wood of the hosts attacked, and since the sporophores vary slightly from those of *P. dryophilus* in form and color, it is very probable that the fungus is a different species.

*Armillaria mellea* Vahl attacks the roots of many species of trees both in our eastern and western forests. It, or a closely related species, is known to attack the following host trees: *Alnus oregona, Betula lutea, B. nigra, Castanea dentata, Larix occidentalis, Pinus contorta, P. flexilis, P. ponderosa, Platanus wrightii, Populus tremuloides, Robinia pseudacacia, Tsuga heterophylla* and various species of Quercus.

## WINTER AND FROST INJURIES TO FOREST TREES

It is not uncommon in mountain valleys, especially in Colorado and to the northward, to note in late spring a killing of the young growing tips of coniferous trees. This takes place during a severe frost or freeze occurring

[1] Published by permission of the Secretary of Agriculture.

[2] Hedgcock, George G. Notes on some diseases of trees in our national forests. II. Phytopathology **2**: 73–80. April, 1912.

after the young ends of the shoots have formed a new growth of leaves. The young leaves and stems being still soft and succulent are apparently killed by the rupture of cells in their tissues. They wilt down and die at once, assuming a reddish tinge or color, and remain in a recurved position. This recurved position and reddened color is common to a number of species of conifers which suffer njury, especially *Abies lasiocarpa*, *A. concolor*, *Picea engelmanni*, *P. parryana*, *Pseudotsuga taxifolia* and *Larix occidentalis*. The injury usually occurs either in narrow valleys and canyons or near where these open into larger valleys or canyons. Such localities are often known as "frost pockets," owing to the frequent recurrence of late frosts in such places. The frequent injury to the trees may give them a ragged appearance, due to an uneven growth of the twigs and limbs.

A second form of injury, a true winter injury, which in some localities has been called the "red belt," occurs in a mild form sporadically in small areas every year in some one of the northern Rocky Mountain states. The last general occurrence in a severe form was during the winter of 1908-1909[3] when 40,000 acres of trees were killed and many more injured in Montana alone. The injury also occurred in isolated localit'es as far east as the Black Hills in South Dakota, and as far south as Colorado.[4]

In this form of injury, which usually occurs either in mid-winter or in early spring, the leaves of conifers redden and dry up, the younger leaves being the most often affected. The growing tip is often killed and even the cambium layer on one side of the tree may be injured, the injury being usually more severe on the west side of the trees affected. It is more common on westerly and north westerly slopes and in narrow belts at certain altitudes, but, in one instance noted, trees on a southerly slope were also injured. During the winter of 1910–1911 such an injury occurred to trees on a series of southerly slopes near Monarch, Montana. Conifers on these slopes exhibited marked indication of injury the following summer, but during the next season they partially recovered, although often presenting a ragged appearance on the northwest side, due to the premature shedding of the leaves and to the death of many of the terminal buds. Trees of the following species, named in order of the injury received, from the greatest to the least, were injured near Monarch: *Pinus contorta*, *Pinus ponderosa*, *Pseudotsuga taxifolia*, *Abies lasiocarpa*, *Pinus flexilis*, *Juniperus scopulorum*, *Juniperus occidentalis* and *Juniperus sibirica*. The last three species suffered only a slight injury to some of the leaves on the upper shoots. Very little or no snow was on the ground at the time the injury took place.

[3] Hedgcock, George G. Winter-killing and smelter-injury in the forests of Montana. Torreya **12**: 25–30. 1912.

[4] Hartley, Carl P. Notes on winter-killing of forest trees. Forest Club Annual (University of Nebraska) **4**: 39–50. 1912.

During the present summer (1912) a small belt of injury of this kind, which had taken place during the winter of 1911–1912, was noted on young lodgepole pines (*Pinus contorta*) near Rollinsville, Colorado, on a westerly slope a few miles east of the continental divide.

Owing to the fact that, in all cases noted, the trees were injured worst on the west side, and the death of the leaves and shoots was apparently a drying-out process, it is believed by many observers that the injury is caused by warm, dry, westerly winds of high velocity which are in the nature of "chinook" winds.[5] These affect only those trees which have their roots immersed in frozen earth. At the higher elevations the early snows cover the earth with a deep blanket, and it is assumed that, as a rule, the roots of the trees in our mountain forests are not encased in frozen earth in mid-winter. A warm spell and thaw often removes all the snow on more exposed slopes at lower elevations, and there is a temporary raising of the snow line to a higher elevation. Severe cold weather without snow freezes the bare ground on these exposed positions, and the trees found here are subject to winter injury, provided that proper air conditions and high, warm, dry, winds occur while their roots are in this condition, even though the frozen earth may afterward be covered with snow. Again, a portion of the forests lower down may be subjected a second time to a thawing-out process, leaving the soil free of frost, only to be followed by a heavy snow, so that both higher up and lower down the earth is not frozen, while mid-way there is a belt of frozen earth beneath the snow. This latter view, which I believe was first advanced by D. T. Mason, Assistant District Forester, is favored by a number of western investigators.

### SMELTER INJURY TO THE FORESTS

A visit was made by the writer in October, 1912, to the region near the great Washoe smelter at Anaconda, Montana. The belt of acute smelter injury in the Deerlodge national forest in the vicinity of Anaconda has been greatly extended during 1911 and 1912, especially during the past growing season. Acute injury to the lodgepole pines has become general in a number of localities from nine to twelve miles from the smelter, where formerly the trees exhibited only the chronic form. The trees in these localities are dying rapidly.

Limber pines (*Pinus flexilis*) on the south slope of the hills adjacent to the smelter on the southwest exhibit the acute form of smelter injury this season and are dying slowly. A study of the cells of the leaves of this species of pine and of the two species of Juniper also present, reveal the fact that these species, which have been considered resistant to smoke,

[5] Hartley, Carl P. Loc. cit., p. 46.

do suffer injury from the fumes, even where the leaves are not apparently injured. The accretion rings of the wood of *Pinus flexilis*, even at a distance of ten miles from the smelter, show a gradual diminution of growth in recent years, and it is a grave question whether it would be possible to reforest with this species in the smelter zone by the process of artificial planting. Within the region of acute injury no fertile seeds were found in the cones of any species of conifers, with the exception of the junipers. This proves that there is no hope of natural reforestation in this region under the existing conditions.

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# ABNORMAL ROOTS OF FIGS

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WITH PLATE XI

Several small branches taken from cultivated fig trees, which for a number of years have either failed entirely to set fruit or have produced only a small crop, were recently sent me for examination as to the cause of this condition. Upon these twigs were numerous cylindrical or conical outgrowths 3 to 5 mm. in length and 1 to 2 mm. in diameter at the base. It was found upon visiting the orchard subsequently that these processes were present also upon the trunk and larger branches, occurring for the most part upon the lower side of the limbs or on the north side of the trees. These outgrowths may be more or less grouped or isolated as shown in figure 2, and in the young condition show a fissure in the cortex, indicating that they have been formed from the underlying tissues and have penetrated the bark upon emergence.

Outgrowths similar in appearance, and apparently similar in structure, have been observed from time to time both on herbaceous and woody plants, but so far as is known no previous account has been made of their occurrence on cultivated figs. Kissa (1) described them as "Kropfmaser" on *Pirus malus chinensis*, Jaeger (2) on apples, Sorauer (3) on *Ribes nigrum*, *Prunus padus*, *Cydonia vulgaris*, and on species of Acer and Tilia. Among the writings of Meyen, Göppert, Schlacht, Trécul, Dutrochet, Hartig, Masters and Frank one may find descriptions of these pathological formations. The so called "chichi" of *Gingko biloba* (4) is of the same nature. The cylindrical processes of Gingko, the smaller of which are the size of one's finger and the larger 2.2 meters in length and 30 cm. in diameter, resemble twigs, except that no leaves are developed unless they come in contact with the soil, in which case roots may also be formed. In cross section they reveal annual rings, continuous with those of the branch. The outgrowths on figs, however, reveal no evidence of a yearly increment of growth.

Several cuttings of these diseased figs were placed in moist soil under bell jars to permit the further development of the processes. All of the outgrowths which were buried in the soil continued to grow as is shown in figure 1, so that within ten days many of them were an inch or more in length. Those above the surface of the soil exhibited no developmental changes,

but in the course of time new outgrowths, similar to those already present, were formed. An examination of the anatomy of these cylindrical growths from transverse and longitudinal sections adds further evidence to the fact that they are roots which have arisen from dormant buds. They are found to possess radial vascular bundles with a tetrarch arrangement of the elements.

Various explanations have from time to time been given to account for hyperplastic development of this sort in plant tissues. Frank (5) regards the large projections as due to adventitious buds and the smaller ones to an abnormal increase in size and form of the medullary rays. In the case of Gingko (4) the formation of "masercylinder" could always be traced back to a latent bud, and provisional buds developed from it. In certain other plants the processes have been described as outgrowths of cortical tissue. Sorauer (3, p. 385) found that gooseberries which grew near a compost heap formed these projections, indicating that there was a local plasmatic derangement in certain tissues, the over supply of food having tended to produce a change in turgor. Kenjiro Fujii (4) suggests that the formation of "masercylinder" of Gingko is accompanied by an indication of local increase of nourishment. Frost injury has been regarded as an inciting cause. Mites and lice may exercise an influence in initiating the development of outgrowths. However, the development by figs of processes which are morphologically roots and which may be made to function as roots if they are brought in contact with the soil, seems to be primarily a response to a superabundance of moisture. The annual rainfall for the locality in which the trees are growing is between 60 and 70 inches. Further than this the affected trees are so shaded and protected against suitable air drainage by buildings and other trees that the growth of vegetation on the ground floor is completely inhibited. The absence of direct illumination seems, however, to be only an indirect factor, judged from experiments in which new outgrowths were formed by plants placed under bell jars and exposed to direct sunlight.

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EXPLANATION OF PLATE XI

FIG. 1. A twig which was placed in wet soil to the bud at *a*.

FIG. 2. The projections have grown into true roots. Twigs taken from trees which show the numerous processes. Almost natural size.

PLATE XI

ABNORMAL ROOTS OF FIGS

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# THE JONATHAN SPOT ROT[1]

MEL. T. COOK AND G. W. MARTIN

One of the most troublesome storage rots of apples in New Jersey is the so-called "Jonathan spot." The spots appear soon after the fruit comes from cold storage and may also occur on mature fruit in the orchard, especially when it is picked late. They are small, seldom more than 1 cm. in diameter, usually circular, brownish or black in color and slightly sunken. In most cases the point of infection appears to be through the lenticels, but infections may occur through fruit cracks and other slight wounds. The diseased tissue is dry, shallow and may be readily separated from the healthy tissue. It can be easily distinguished from the Baldwin spot and from the New Hampshire fruit spot. The writers have also found what appears to be the same disease on Nero, Smokehouse and Newtown Pippin.[2]

Cultures were made from these spots by means of the following method. The surface of the fruit was thoroughly disinfected with a 5 per cent formalin solution and then washed with sterilized water. The peel from the large spots was removed with a sterile knife and small bits of the tissue were put in petri dishes containing culture media. In the case of the extremely small spots the cut surface of the bit of peel was placed directly against the medium. Fully 90 per cent of these cultures, including those made from the smallest spots that we were able to detect, gave luxuriant and characteristic growths of Alternaria.

Repeated inoculation experiments indicate that the organism which we isolated from the Jonathan spot can cause typical spot rot. However, our inability to secure Jonathan apples which were absolutely free from the disease made these experiments unsatisfactory. Our checks almost invariably developed the spots and therefore our only method of determining the effect of the inoculations was by counting the spots, which necessarily made the results inconclusive.

An Alternaria rot was first reported as attacking both apples and pears by Longyear of Colorado, in 1905, who also reported finding an Alternaria

[1] Read before the American Phytopathological Society at Cleveland, O., January 2, 1913.

[2] Since the presentation of this paper, Scott and Roberts have reported a "Jonathan spot," which they consider a physiological trouble, on Jonathan, Esopus, Yellow Newton, Grimes Golden and Arkansas Black. U. S. Dept. Agr., Bur. Pl. Ind. Circ. 112. February 8, 1913.

in the cores of apples from California. This disease, however, was strictly a blossom-end and core rot and is not mentioned as being the cause of a spot rot. We also have collected Alternaria blossom-end and core rots from Gravensteins and White Ohio Pippins in New Jersey, but the organisms would not cause the Jonathan spot, nor did they seem to be quite the same as the Alternaria isolated from the typical Jonathan spots. Furthermore, cultures from core rots in western Winesaps gave two Alternarias, one with long and the other with short spores, but both failed to produce Jonathan spot rot, although the former would readily produce a soft rot. This appears to indicate that the Colorado blossom-end and core rot is different from the New Jersey Jonathan spot rot but may be the same as the New Jersey blossom-end and core rot. Storage rot due to Alternaria has also been reported by H. J. Eustace, but there is no way of determining which particular form is responsible. Morse and Lewis reported an Alternaria from Maine in 1910 as causing a blossom-end rot and also as attacking the fruit through wounds, but they did not connect this organism with the forms occurring on the twigs and foliage.

It appears to the writers that we have at least three different species or varieties of Alternaria causing apple rots: (1) one causing a blossom-end and core rot, which is probably very widely distributed throughout the country; (2) one causing a dry spot rot on the Jonathan, and probably on other varieties, and distributed over a more restricted area; (3) one or more either causing or following storage rots.

This disease is becoming more and more severe in New Jersey and it is very evident that our orchard treatments must take it into consideration. The data secured up to the present time indicate that the infection occurs in the orchard and that the susceptibility of the various varieties depends on the character of the lenticels. The time of infection and the method of treatment are still undetermined but work will be carried on throughout the coming year.

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# STUDIES ON THE WATER CORE OF APPLE

P. J. O'Gara

With Two Figures in the Text

Water core of apple is a trouble which is not restricted to any one district where apples are grown, but is found to occur more or less generally over the country, particularly in the arid and semi-arid districts. Reports of this trouble have also come from apple growing districts of Europe, Asia and Africa. Although the trouble has been known for some time, data of very little importance is be to found in American plant pathological and physiological literature. It seems that very little serious work has been done in the matter of determining the true cause of the disease. Some European writers have held that the disease is caused by bacteria, although others have shown that the trouble is not due to any parasitic agency.

The writer has done considerable work on this disease during the past few years, and in no case has it been possible to identify any organism as the causative agent. All the methods known to modern bacteriology especially those used in the study of ultra-microscopic organisms, have failed to show the presence of any organism. Numerous attempts have been made to inoculate healthy fruits by injecting the juice from water-cored spots of diseased apples, but in no case did the inoculated fruits develop any symptoms of water core. In a previous paper[1] the writer mentions the presence of various organisms, especially *Alternaria sp.*, in connection with his studies on water core, but in no case could it be shown that any organism caused the disease.

The characteristic appearance of water-cored apples is so well known that a minute description is hardly necessary here. The affected apples have hard watery areas extending outward from the outer edges of the seed cavities. In the beginning stages, the first appearance of water core is in connection with the vascular system. Each bundle will show a water-soaked area surrounding it, and, as a rule, this area makes its appearance a short distance from the stem. As the vascular system is variously branched upward, water-soaked areas may appear at almost any place in the fruit. In later stages the seed cavity usually contains liquid, and the hard inner membrane of the carpels is cracked and covered with hair-like growths

[1] O'Gara, P. J. Water Core of Apple. Office of the Pathologist and Entomologist for Rogue River Valley, Medford, Oregon. Bulletin 9. October 11, 1912.

which finally assume a brownish appearance. The fruit has a somewhat sweetish, fermented flavor, and the watery parts contain more sugar and less acid than the normal or unaffected parts. It is during the later stages of the disease, especially where cracks appear in the calyx- or blossom-end, that we find fungi and bacteria present. *Alternaria sp.* is a common intruder, and produces a serious core rot. This latter trouble, namely, Alternaria infection, may be prevented by the proper and timely application of Bordeaux mixture.

During the past season the writer has had the good fortune to be able to do some very interesting work in connection with water core. It was found that conditions affecting transpiration are the prime factors inducing this disease. (I use the term "disease" because I believe that it is just as correct in this case as though the trouble were due to a parasitic organism.) The conditions affecting transpiration in plants are so well known to plant physiologists that I need not enumerate them here. Before giving the data upon which my conclusions are based, I shall enumerate the conditions favoring water core. It must be understood that no single condition may produce water core; as a rule, it is a combination of perhaps two or more factors. In some cases avoidance of the trouble may be possible; however, for the most part, it is entirely impossible to prevent it because of the fact that certain climatological factors enter into the problem. The most prominent factors inducing water core are:

1. Excessive or strong vegetative growth, especially in young trees just coming into bearing. Such trees usually set light crops and the fruits are abnormal in size. Fruits borne far out on the terminals are very liable to water core, whether the trees are old or young, providing the trees are vigorous. Trees making poor growth, which may be caused by soil conditions, lack of moisture, root trouble, or any other cause, rarely show water core in the fruit.

2. High cultivation is a factor, but alone would not cause the trouble. However, well cultivated soils retain moisture much better than those which are not cultivated, hence, as a rule, high cultivation will promote vigorous growth and, therefore, favors water core, providing other factors are present.

3. Excessive precipitation or irrigation shortly before the maturity of the fruit, if followed by great extremes of temperature and atmospheric humidity, are factors of the greatest importance. During hours of sunshine the moist ground is warmed to such an extent that water is readily taken up by the root system, and at this time transpiration is also very rapid. During the night the atmospheric temperature lowers to the point of saturation, this often being very little above the freezing point; however, the moist soil in which the roots are growing remains warm, or at least several degrees

above that of the air temperature. Under such conditions, sap pressure is continuous, but transpiration is checked. Evaporation cannot take place from any surface when the surrounding medium (air, in this case) has reached the point of saturation. With transpiration checked and the sap pressure continuing, the tissues along the lines of greatest pressure must give way. These tissues are found in the fruits, especially those farthest out on the terminals, because they are exposed to extremes of temperature. Fruits on the south or southwest sides of trees are always most affected.

4. Severe pruning shortly before the ripening period, or defoliation by disease or otherwise, thus causing the fruit to be exposed as well as reducing the evaporation surface of the tree, will have a tendency to produce water core.

5. Frosts, which are severe enough to injure the foliage, have an effect similar to that of defoliation, since leaves which are so injured no longer function as true agents of transpiration. Certain chemical activities are also set up in plants after frosts have injured them, and this produces rapid ripening in the case of apples. It is quite noticeable after a heavy frost that apples color rapidly, this being due to the formation and activity of certain enzymes.

6. Cell tension or turgor may be induced by the rapid conversion of starch into sugar. This tension may be caused in two ways: (1) by the rapid absorption of water by the sugar through osmotic pressure; (2) by the rearrangement of the molecules during the process of starch conversion into sugar. This, however, is of less importance than the other factors enumerated above.

The weather conditions which favored water core during this season, particularly in this district, are shown in the accompanying tables of temperature, relative humidity and precipitation for the period beginning August 26 and ending September 30, 1912. The thermograph records showing the peculiarity of the temperature curves are also given. For convenience in showing the relationship between temperature and humidity, the extremes of relative humidity in percentages are shown graphically on the thermograph records. This is done because there was no hygrograph at hand to trace the actual relative humidity curves. The months of July and August were particularly dry, the precipitation for July being 0.20 inches, and for August 0.07 inches. During this period practically clear weather prevailed. Beginning with August 31 and ending September 8, 1.15 inches of rain fell. Following this period of moderate temperatures came three weeks of clear weather with high temperatures during the hours of sunshine and low temperatures during the nights. As will be seen by inspecting the table and the thermograph records for this period, the daily range of temperature reached as high as 48°F. The difference in relative

TABLE I

*Maximum and minimum temperatures, relative humidity, precipitation and state of weather. United States Weather Bureau Station, Medford, Oregon, August 26 to September 30, 1912*

| DATE | TEMPERATURE | | | RELATIVE HUMIDITY | | | PRECIPITATION | STATE OF WEATHER |
|---|---|---|---|---|---|---|---|---|
| | Max. | Min. | Range | 5.00 a.m. | 5.00 p.m. | Range | | |
| | °F. | °F. | °F. | per cent | per cent | per cent | inch | |
| August | | | | | | | | |
| 26 | 80 | 54 | 26 | 83 | 29 | 54 | 0 | Cloudy |
| 27 | 72 | 56 | 16 | 82 | 44 | 38 | 0 | Cloudy |
| 28 | 71 | 55 | 16 | 82 | 39 | 43 | 0 | Clear |
| 29 | 71 | 39 | 32 | 87 | 23 | 64 | 0 | Cloudy |
| 30 | 77 | 40 | 37 | 89 | 38 | 51 | 0 | Cloudy |
| 31 | 69 | 51 | 18 | 88 | 53 | 35 | 0.04 | Cloudy |
| September | | | | | | | | |
| 1 | 74 | 47 | 27 | 87 | 37 | 50 | 0 | Partly cloudy |
| 2 | 60 | 46 | 14 | 55 | 54 | 1 | 0.04 | Cloudy |
| 3 | 60 | 46 | 14 | 87 | 57 | 30 | 0.06 | Cloudy |
| 4 | 68 | 48 | 20 | 93 | 39 | 54 | 0.03 | Partly cloudy |
| 5 | 64 | 49 | 15 | 93 | 58 | 35 | 0.10 | Cloudy |
| 6 | 56 | 47 | 9 | 93 | 65 | 28 | 0.70 | Cloudy |
| 7 | 64 | 46 | 18 | 86 | 73 | 13 | 0.01 | Cloudy |
| 8 | 68 | 47 | 21 | 93 | 47 | 46 | 0.14 | Partly cloudy |
| 9 | 76 | 40 | 36 | 69 | 34 | 35 | 0 | Clear |
| 10 | 84 | 43 | 41 | 86 | 23 | 63 | 0 | Clear |
| 11 | 84 | 43 | 41 | 78 | 31 | 47 | 0 | Clear |
| 12 | 86 | 44 | 42 | 79 | 26 | 53 | 0 | Clear |
| 13 | 90 | 47 | 43 | 79 | 23 | 56 | 0 | Clear |
| 14 | 90 | 49 | 41 | 81 | 24 | 57 | 0 | Clear |
| 15 | 88 | 54 | 34 | 82 | 20 | 62 | 0 | Clear |
| 16 | 77 | 47 | 30 | 87 | 51 | 36 | 0 | Clear |
| 17 | 74 | 55 | 19 | 82 | 40 | 42 | 0 | Partly cloudy |
| 18 | 86 | 45 | 41 | 79 | 34 | 45 | 0 | Clear |
| 19 | 86 | 47 | 39 | 81 | 29 | 52 | 0 | Clear |
| 20 | 90 | 46 | 44 | 73 | 17 | 56 | 0 | Clear |
| 21 | 89 | 44 | 45 | 79 | 18 | 61 | 0 | Clear |
| 22 | 84 | 45 | 39 | 80 | 27 | 53 | 0 | Clear |
| 23 | 77 | 40 | 37 | 85 | 39 | 46 | 0 | Clear |
| 24 | 76 | 36 | 40 | 92 | 28 | 64 | 0 | Clear |
| 25 | 84 | 36 | 48 | 92 | 20 | 72 | 0 | Clear |
| 26 | 87 | 39 | 48 | 92 | 17 | 75 | 0 | Clear |
| 27 | 75 | 48 | 27 | 67 | 59 | 8 | trace | Cloudy |
| 28 | 76 | 51 | 25 | 88 | 54 | 34 | trace | Partly cloudy |
| 29 | 80 | 48 | 32 | 87 | 32 | 55 | 0 | Clear |
| 30 | 70 | 45 | 25 | 93 | 63 | 30 | 0.03 | Partly cloudy |

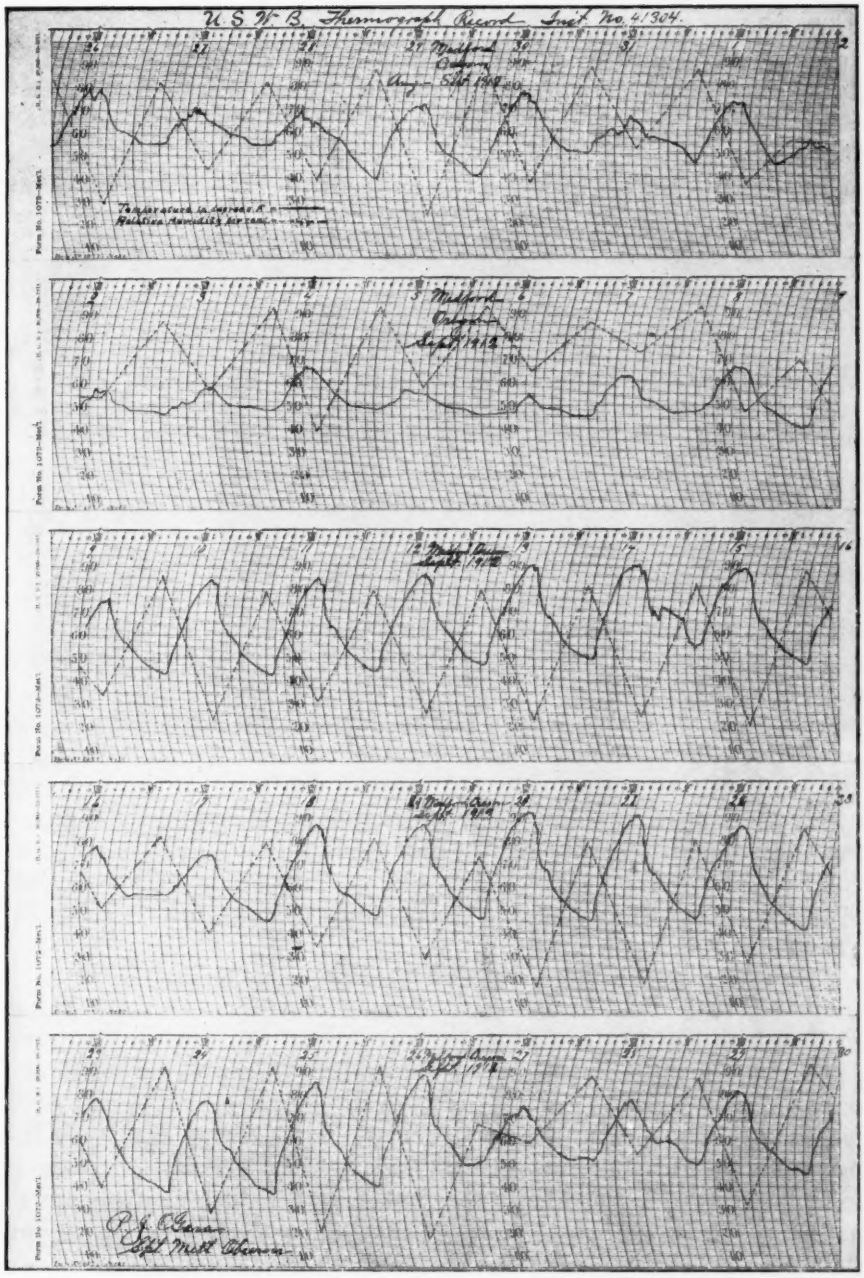


FIG. 1. THERMOGRAPH RECORDS WITH RANGE OF RELATIVE HUMIDITY, MEDFORD, OREGON, AUGUST 26, TO SEPTEMBER 30, 1912

The full lines show temperature degrees Fahrenheit. The dotted lines indicate percentage relative humidity, and simply mark the extremes.

humidity during a twelve-hour period reached as high as 75 per cent. The table given is taken from the records of the United States Weather Bureau, Medford, Oregon, the readings having been made at approximately 5.00 A.M. and 5.00 P.M. local time, (Pacific time). The 5.00 A.M. readings of relative humidity correspond very closely with the time of minimum temperatures, while the 5.00 P.M. readings correspond fairly well with the time of maximum temperatures. Had the relative humidity readings been taken at the exact time of maximum and minimum temperatures greater extremes of relative humidity would have been observed.

A careful examination of orchards of the same age and variety showed that the amount of water core present in the fruit was in direct proportion to the amount of precipitation or irrigation, range in temperature and range in relative humidity. The records given in the tables are those taken on the valley floor where the range in both temperature and relative humidity was very great. At elevations where this range was not so great, there was very little water core. The amount of precipitation also had its effect. In orchards where the precipitation was light, water core was much less abundant. A very interesting case was noted where the rainfall was supplemented by a heavy irrigation, both preceding and after the rain occurred. In this orchard over 90 per cent of the fruit showed water core, while an adjacent orchard on the same type of soil, with the same varieties of apples, but not irrigated, showed not over 5 per cent of the fruit affected. Another interesting case was noted where an orchard was severely pruned during the latter part of August, exposing most of the fruit. In this orchard, nearly all of the fruit became water-cored, while an adjacent orchard growing under the same conditions, but unpruned, had very little water core. Another orchard where one half the trees were pruned, as above, showed 90 per cent water core in the part pruned, while the unpruned trees did not show more than 5 per cent.

As has been stated before, water core is more liable to occur in exposed fruits, especially those far out on the terminals and those on the south or southwest parts of the tree. In order to prove that this is universally true, I had a large number of boxes of fruit picked from the south and southwest parts of trees by pickers who did not know my purpose. I also had fruit picked from the unexposed parts of trees. In the former case, fully 90 per cent of the fruit showed water core, while less than 5 per cent were found to be water-cored in the latter case. This proved to be a very important matter in the segregation of water-cored fruits preparatory to boxing for shipment.

The examination of water-cored fruit shows that it is water-cored in proportion to its exposure to extremes of temperature and humidity. The side or part of an apple presented to the direct action of the sun's rays will

show more water-soaked tissue than the part not so exposed. In the orchard, or even with the fruit in the boxes, the careful observer may pick out the water-cored fruit, although no evidence of water-soaked tissue may be seen. Usually, water-cored apples have a much higher color than those not affected. In the Newtown, a yellow variety, a blush or colored cheek

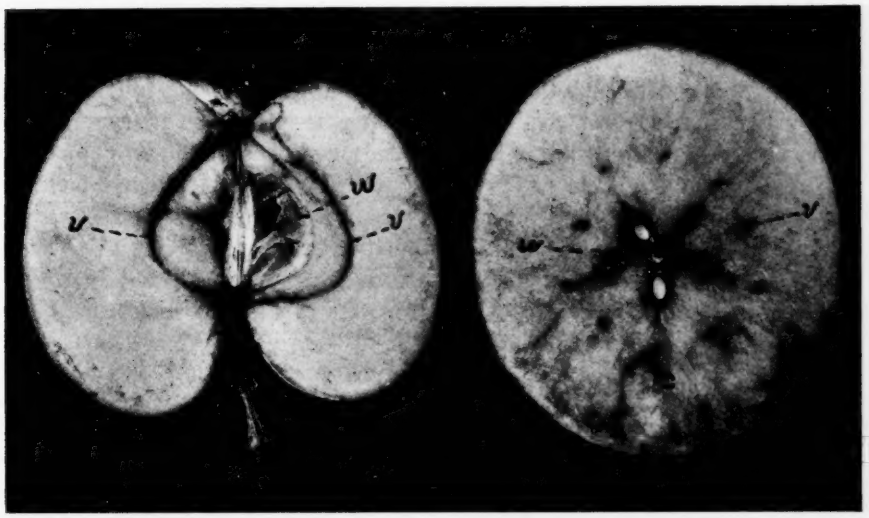


FIG. 2. LONGITUDINAL AND CROSS SECTION OF NEWTOWN APPLE AFFECTED WITH WATER CORE

In both sections of the fruit the parts marked *v* are vascular bundles, which are ten in number. It will be noted in the cross section that the upper bundles show smaller areas of water soaked tissue than the lower bundles which have rather large areas surrounding them showing a water soaked appearance. In the region marked *c* of the cro s section there are large areas of water cored tissue, the injury extending outward to the epidermis. This water soaked area is on the side of the fruit presented to the direct rays of the sun, while the upper side, showing practically no water core, is on the side away from the sun. The cracked carpel with its hairy growths is shown at *w*. It is best seen in the longitudinal section, which also shows very p'ainly the connection of the vascular strands marked *v* with the stem. This fruit was taken from a terminal on the southwest side of a vigorous ten-year-old Newtown tree, and did not outwardly show water core.

usually indicates a water-cored fruit. A normal Newtown should be green when picked. Water core is much more easily detected in yellow than in red varieties of apples.

Under proper storage conditions, water-cored fruit, unless badly affected, will entirely recover. This will be the case where no liquid fills the seed cavities and if the fruit is placed in a cool, even-temperatured place (not

cold storage). The fact that water-cored fruit will become normal, the water soaked spots entirely disappearing under proper storage conditions, demonstrates the non-parasitic nature of the trouble. As soon as it is found that apples are becoming water-cored, they should be immediately picked and placed in proper storage. If allowed to remain on the trees until liquid fills the seed cavities, ultimate recovery is almost impossible. Besides, various organisms gain access to the fruit and complete its destruction.

In an experiment, 1000 boxes of Newtown apples showing fully 90 per cent water core were stored for about three weeks. The percentage of water core was carefully determined before putting the fruit into storage. As far as possible all fruits very badly water-cored and evidently having the seed cavities filled with liquid were not put into storage. At the end of three weeks the fruit was again examined and showed scarcely 1 per cent water core. The only cases not fully recovering were those in which the seed cavities had become filled with liquid, and in which fermentative processes had been set up.

MEDFORD, OREGON

# NOTES ON DISEASES OF TREES IN THE SOUTHERN APPALACHIANS I

ARTHUR H. GRAVES

WITH TEN FIGURES IN THE TEXT

In the summer of 1910 the writer was detailed by the United States Forest Service to make a general survey of the diseases of trees in the southern Appalachian mountains. The work was done in collaboration with the Office of Investigations in Forest Pathology, Bureau of Plant Industry. At the request of the Forest Service, special attention was given to the diseases of four timber trees: i.e., *Pinus virginiana* Mill., *Quercus rubra* L., *Castanea dentata* (Marsh.) Borkh., and *Liriodendron Tulipifera* L. A small part of the results of this work has already been incorporated in a bulletin by W. D. Sterrett.[1]

In addition to the work on these four species, notes and collections were made of all fungi which were found to be associated with disease in other tree species. Saprophytic fungi attacking wood were also collected, and a list of these will be given later. One set of these specimens has been added to the herbarium of the Office of Investigations in Forest Pathology, Bureau of Plant Industry, and a duplicate set, sent to Yale University, is preserved in the Eaton Herbarium of that institution.

In the study of this material during the past two years, several hitherto undescribed or little known diseases have been found. An account of one of these[2] has already been published. It is the purpose of the writer in the following notes, the first of a series of papers, to bring together the most important data obtained in this work in the field and from subsequent study in the laboratory, including also distributional notes on the better known diseases; in order that they may be of assistance in furthering our knowledge of the diseases of trees in this region.

The diseases will be treated according to host species, the arrangement of hosts following that of Sudworth's Check List of the Forest Trees of the United States.[3]

[1] Sterrett, W. D. Scrub pine (Pinus virginiana). U. S. Dept. Agr., Forest Service Bul. 94: 1–27, figs. 1–2. July, 1911.

[2] Graves, Arthur H. The large leaf spot of chestnut and oak. Mycologia **4**: 170–174. 1912.

[3] Sudworth, George B. Check list of the forest trees of the United States. U. S. Dept. Agr., Forest Service Bul. 17: 1–144. 1898.

## SOME DISEASES OF THE WHITE PINE (PINUS STROBUS L.)

### BARK BLIGHT. *Coccomyces Pini* (Alb. & Schw.) Karst.

This was observed on two living white pines near Tallulah Falls, Georgia. The trees were about 1 foot in diameter, breast high, and apparently healthy as regards the leaves and the main trunk. Many of the branches, however, which indeed still had healthy leaves, showed a reddish stripe in the bark, extending for a considerable distance longitudinally,

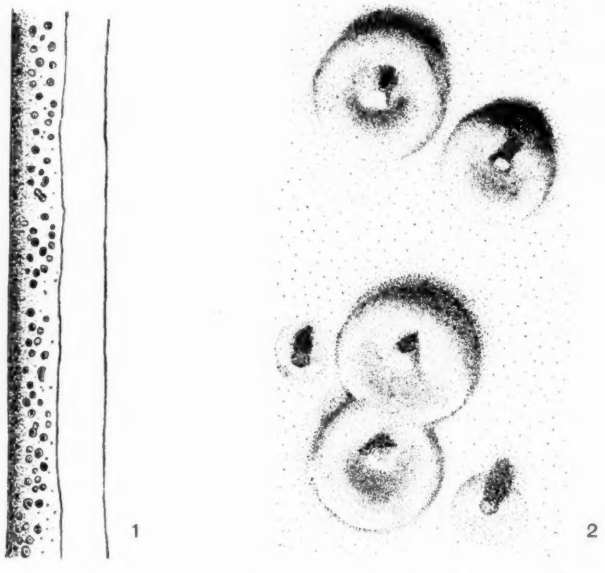


FIG. 1. Part of diseased branch; showing lesion (stippled portion) and fruiting bodies. × 2.

FIG. 2. Fruiting bodies of Coccomyces Pini (Alb. & Schw.) Karst. × 45.

and occasionally taking up as much as an inch of the branch circumference, though usually somewhat less than this. These stripes showed a fairly even demarcation from the healthy bark (fig. 1), so that the contrast between the red-brown of the diseased portion, and the brownish-green of the healthy part was strongly marked. It should be noted also that in many cases the terminal portions of the branches thus attacked were entirely diseased and dead.

On the diseased portions fruiting bodies of a fungus were clearly apparent to the naked eye. These varied considerably in size and shape between

two extremes: i.e., from the larger type, which is a low disc-like protuberance, often 1 mm. in diameter, with a central concavity in the middle of which the papillate opening into the interior appears—passing through smaller sizes of this same structure, where no concavity appears—to the form in which simply a black pustule, raised a slight distance above the bark, indicates the opening into the interior of the fruiting body (fig. 2). All intergradations between these two extreme types were found, so that it seemed unreasonable on account of the form alone to regard them as two forms of fruiting bodies. Cross sections revealed large numbers of filiform, hyaline, one-celled spores, usually straight, but sometimes slightly curved (fig. 3). These were found in all the forms of fruiting bodies, so that the latter may properly be regarded as pycnidia. However, it should be stated that the ascigerous form, or apothecium, in the exsiccati examined by the writer, corresponds in external appearance to the larger form of pycnidium.

The fungus is the imperfect form of *Coccomyces Pini* (Alb. & Schw.) Karst., a member of the Phacidiaceae; a plant which has several synonyms, chief of which are *Coccophacidium Pini* Rehm[4] and *Phacidium Pini* Fr.[5] Exsiccati distributed under the latter name by Rabenhorst (Fungi Eur. *3568*. 1886) and De Thuemen (Myc. Univ. *179*. 1875) have been examined and correspond with the species in question. Saccardo's[6] description assigns a diameter of 1.5 to 4 mm. to the fruiting bodies, but since these figures refer to mature apothecia, such a disparity might be expected. The pycnospores in our specimens average 7.5 x 0.6$\mu$, figures which are not greatly at variance with those given by Saccardo—10 x 1$\mu$ (fig. 3). As is characteristic of the fruiting body of the Phacidiales, at maturity a cracking open of the covering in a more or less star-shaped form occurs (fig. 4).

Judging from the manner in which this fungus appears on the living branches, the writer is inclined to the belief that it is a facultative parasite, for, as already intimated, besides its frequent occurrence in the long discolored strips surrounded by the healthy bark, it often entirely envelops the smaller, terminal twigs, which are quite dead, apparently as a result of its attack. On the other hand, it is quite possible that its attack is of a secondary nature: i.e., preceded by injury to the branches from drought, cold, sun-scald, etc. A point in favor of this view is the location of the disease often on a definite strip of bark, a condition which gives the appearance of the exposure of a portion of the branch to some external injury of the sort mentioned. The question, however, can only be conclusively

[4] Rehm, H. In Rabenhorst's Kryptogamen-Flora von Deutschland, Oesterreich und der Schweiz. **1**[3]: 98. 1896.

[5] Fries, E. Systema mycologicum **2**: 573. 1822.

[6] Saccardo, P. A. Sylloge Fungorum **8**: 748–749. 1889.

FIG. 3. Cross section through pycnidium of Coccomyces Pini (Alb. & Schw.) Karst. × 440.

settled by thorough inoculation experiments. Unfortunately, when the study of the disease was taken up, the spores were no longer viable. But it is important to note in this connection that Köck[7] records a case of apparent parasitism on the Scotch pine (*Pinus sylvestris* L.) due to *Coccophacidium Pini*, a name which, as has been stated, is synonymous with *Coccomyces Pini*.

HEART ROT. *Trametes Pini* (Brot.) Fr.

A case of the disease of white pine caused by this fungus, well known to be very destructive, was observed near Fairfield Lake, Jackson County, North Carolina. A large living tree about four feet in diameter, breast high, had recently been blown over, and examination of the interior of the trunk showed the wood to be composed of the characteristic dote resulting from decomposition by the mycelium of *Trametes Pini*. Although no

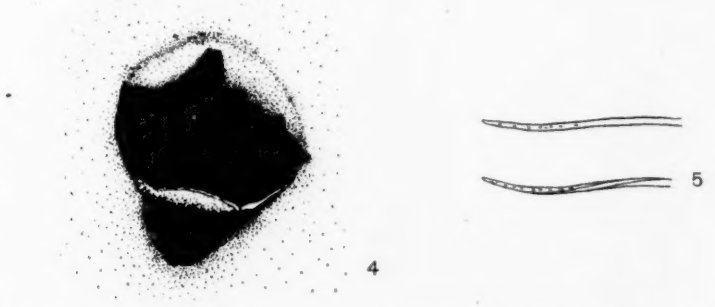


FIG. 4. Old fruiting body of Coccomyces Pini, after shedding of the spores. × 60.
FIG. 5. Fruiting bodies of Lophodermium brachysporum Rostrup on leaves of Pinus Strobus. Natural size.

fruiting bodies were found, the white spots distributed rather regularly through the wood rendered the identity of the fungus easily recognizable. This case was a good example of the way in which a fungus causing heart rot can indirectly bring about the death of a tree by weakening its mechanical support, and thus render it susceptible to windfall.

LEAF BLIGHT. *Lophodermium brachysporum* Rostrup.

Leaves on which this fungus occurred were at first light yellow, turning to a light reddish brown; in the final stages, a deep brown, which occasionally takes on a grayish cast. The fungus is characterized by its smooth and shining, black fruiting bodies, elliptical in outline, elongated parallel

[7] Köck, G. Ueber ein scheinbar parasitäres Auftreten von Coccophacidium Pini auf Kiefer. Oesterr. Forst-u. Jagdztg. **28**: 38. 1909.

with the long axis of the leaf, and arranged at more or less regular intervals along the leaf, usually on its outer surface: i.e., that surface which is oriented toward the exterior of the leaf fascicle (fig. 5). On examination with a hand lens each fruiting body is seen to be perforated, also parallel to the long axis of the leaf, by a narrow median slit whose edges approach so closely

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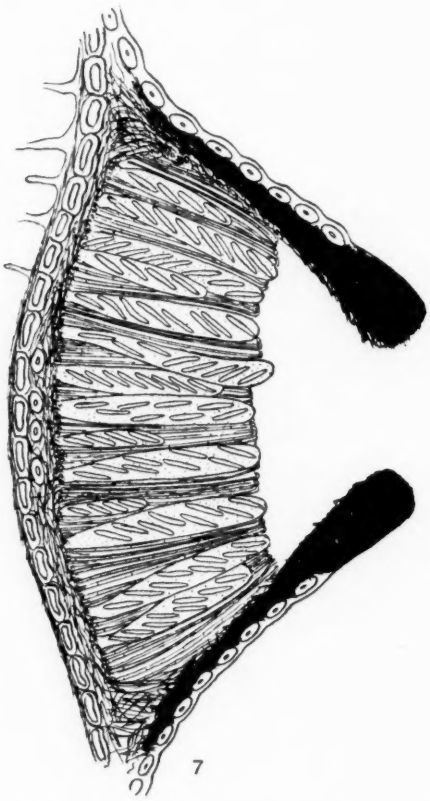

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FIG. 6. Fruiting bodies of Lophodermium brachysporum on leaves of Pinus Strobus. × 20.

FIG. 7. Cross section through apothecium of Lophodermium brachysporum Rostrup. × 250.

that the opening into the interior is almost imperceptible to the naked eye (fig. 6).

A cross section through such an apothecium is shown in figure 7. The club-shaped, sessile asci, in our specimens averaging 110 x 16$\mu$, are plentifully intermingled with filamentous, septate paraphyses, which also line

the wall of the apothecium up to about the height of the asci. Tubeuf[8] has figured and described the paraphyses as being clavate at the apex, but our material shows besides the clavate ending a variety of other terminations, all occurring in the same apothecium (fig. 8b).

Externally the species resembles very strongly *Lophodermium Pinastri* Schrad., the well-known "schüttepilz," which has caused so much destruction in Europe. But from its comparatively short spores it is readily distinguishable from *L. Pinastri*, the spores of which are filamentous, arrange side by side, and extend nearly the length of the ascus. The mature spores are said to be at length two-celled, but only one cell appeared in our speci-

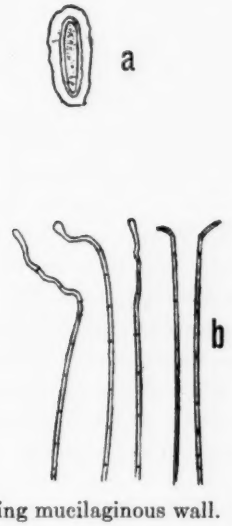


FIG. 8. *a*. Spore, showing mucilaginous wall. *b*. paraphyses. × 380.

mens, although the apothecia seemed mature. Fron[9] figures and describes them as containing four cells. The mature spore, as Tubeuf[10] has described and figured, is surrounded by a thick sheath of slime (fig. 8a). Exclusive of this sheath the spores averaged 24 x 3.25$\mu$. They are normally borne in two rows in the ascus, but this double row, when viewed laterally, of course appears as a single one.

It is the writer's belief that this species is identical with *Hypoderma Desmazierii* Duby, which was collected in France on leaves of various pines

[8] Tubeuf, C. von. Beiträge zur Kenntniss der Baumkrankheiten, p. 36. Berlin, 1888.

[9] Fron, G. Maladie du Pinus Strobus déterminée par Lophodermium brachysporum Rostrup. Bull. Soc. Myc. France **27**: 44–46. *f.1.* 1911.

[10] Tubeuf, loc. cit., p. 36.

by Desmazières. Although, unfortunately, Duby[11] gave no measurements, his description and figures tally closely with the fungus in question. Moreover, the spore measurements given for *Hypoderma Desmazierii* by Ellis and Everhart,[12] 15–22 x 2.5–3$\mu$, are very close to ours, and it is important to note that they differ very little from those of Saccardo[13] and Rostrup[14] for *Lophodermium brachysporum*.

Briefly, the nomenclatural history of *Lophodermium brachysporum* is as follows: The species was described in 1883 by Rostrup.[15] Later, Tubeuf[16] noted the same fungus on the white pine in Germany, and in his description, published in 1888, retained Rostrup's name. But in his Pflanzenkrankheiten,[17] published in 1895, evidently realizing that the short spores of the species are more characteristic of the genus Hypoderma, he changed the name to *Hypoderma brachysporum* (Rostrup) Tub. Finding, however, as he says later, (1897),[18] that there already existed a *Hypoderma brachysporum* described by Spegazzini[19] in 1887, and growing on the leaves of a species of Berberis, he renamed the species *Hypoderma strobicola*. In 1896, however, Rehm,[20] in disregard of this species of Spegazzini, had republished the description of the species under the name *Hypoderma brachysporum* Rostrup. Recently, Tubeuf[21] (1908) has again noted the fungus under the name *Hypoderma* (*Lophodermium*) *brachysporum*. Since the species of Spegazzini is valid, and has priority, reference to our fungus as *Hypoderma brachysporum* is contrary to the rules of nomenclature. But its short spores place it more properly in the genus Hypoderma than in Lophodermium. It would seem advisable, therefore, if this is the same fungus as that described by Duby, to revive his earlier name. A final decision of the question, however, must rest upon a careful comparison of our form with

[11] Duby, J. E. Mémoire sur la tribu des Hystérinées de la famille des Hypoxylés (Pyrénomycètes). Mem. de la Soc. de Phil. de Genève **16**: 15–70. *pl. 1–2*. 1862.

[12] Ellis and Everhart. Pyrénomycètes, 713. 1892.

[13] Saccardo, P. A. Sylloge Fungorum **9**: 1125. 1891.

[14] Rostrup, E. Fortsatte Undersogelser over Snyltesvampes Angreb paa Skovtraernes (med systen Trosnit). Tidsskrift for Skovbrug **6**: 199–300. 1883.

[15] Rostrup, E. loc. cit.

[16] Tubeuf. C. von. loc. cit.

[17] Tubeuf, C. von. Pflanzenkrankheiten durch kryptogamen Parasiten verursacht, p. 247. 1895.

[18] Tubeuf, C. von, and Smith, W. G. Diseases of Plants Induced by Cryptogamic Parasites, p. 233. Note. 1897.

[19] Spegazzini, C. Fungi Fuegani. Boletin de la Academia nacional de Ciensias de Cordoba **11**: 116. 1887.

[20] Rehm, H. Ascomyceten, in Rabenhorst's Kryptogamen-Flora von Deutschland, Oesterreich und der Schweiz **1**[3]: 1211. 1896. (Second edition.)

[21] Tubeuf, C. von. Die Nadelschütte der Weymouthskiefer, ein Beitrag zur Kenntnis der Krankheiten der Exoten. Naturw. Zeitschr. f. Land- u. Forstw.**6**: 326–330, f. 3. 1908.

the type specimens of *Hypoderma Desmazierii* Duby, which the writer has not yet been able to obtain.

*Hypoderma Desmazierii* Duby has been collected in this country by Peck and Gerard[22] and by Dearness in Canada.[23] Recently, Clinton[24] has noted it as doing some damage to the leaves of the pitch pine (*Pinus rigida* Mill.).

The fungus associated with the leaf blight treated in this paper was observed to be of common occurrence on a four or five year old plantation of white pine near Highlands, North Carolina, and also on a somewhat older plantation near Fairfield Lake, North Carolina. The same disease has also been observed this winter, (January, 1913), on a fourteen year old plantation near New Haven, Conn.

As far as the writer can ascertain, no infection experiments have as yet established the parasitism of *Lophodermium brachysporum* Rostrup. On the nearly related species, *Lophodermium Pinastri* (Schrad.) Chev., however, Prantl[25] demonstrated parasitism in 1877 by infection experiments, and recently Haack,[26] in a thorough study of the "schüttepilz." has confirmed Prantl's results. In the case already referred to of the disease caused by *Lophodermium brachysporum* near New Haven, it often happened that one or more short sections of the leaf were attacked, in which the yellower color of the diseased portions stood out as distinct bands, in marked contrast to the clear green of the healthy parts of the leaf. This condition was not observed in North Carolina, possibly because the disease there had progressed beyond this point. Without enlarging on this fact, it is sufficient to state that it would seem to indicate a condition of parasitism. The writer hopes, with this fresh New Haven material, to be able soon to carry on infection experiments.

As to the amount of damage caused by this fungus Rostrup[27] states that it is a dangerous parasite on the white pine in Denmark. Tubeuf,[28] in 1888, described the disease as causing considerable damage in Germany, and recently[29] has issued a note of warning to German foresters to beware of its presence.

That the fungus also attacks the main stems of seedlings and the twigs of larger trees is generally accepted by European investigators, such as Ros-

[22] Saccardo, P. A. Sylloge Fungorum **2**: 786. 1883.

[23] Ellis and Everhart. loc. cit.

[24] Clinton, G. P. Conn. Agr. Exp. Sta. Rept. **1906**: 319. May, 1907.

[25] Prantl, K. Hysterium Pinastri Schrad. als Ursache der Schüttekrankheit der Kiefer. Vorläufige Mittheilung. Flora, N. S., **35**: 333–336. 1877.

[26] Haack. Der Schüttepilz der Keifer. Zeitschr. f. Forst-u. Jagdwesen. **43**: 329–357; 393–423; 481–505, pl. 1. 1911.

[27] Rostrup, E. loc. cit.

[28] Tubeuf, C. von. (1888), loc. cit.

[29] Tubeuf, C. von. (1908), loc. cit.

trup, Tubeuf, Haack, and Fron.[30] The last mentioned states definitely that the mycelium descends from the leaves into the branches, at first into the cortical zone, chiefly in the large resin ducts there, then into the medullary rays, the resin ducts of the wood, and extends even into the tracheids of the spring wood. By its presence it soon puts a stop to the activity of the cambium and so brings about the dessication and death of the branch. Spaulding,[31] who mentions the frequent occurrence of the fungus on the leaves of the white pine in this country, has also recorded it as the causal

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FIG. 9. Abnormal fruiting bodies (?) on leaf of Pinus Strobus × 20.

FIG. 10. Showing transition from abnormal to normal form of fruiting body. Natural size.

organism in a twig blight of the same species. Stevens and Hall,[32] in treating of the diseases of the white pine, include the twig and leaf blight caused by this fungus.

Among the specimens collected by the writer, those from the young plantation near Highlands, North Carolina, showed in many cases a dying out of the terminal portion of the shoot, which was completely defoliated, but

[30] Fron, G. Loc. cit.

[31] Spaulding, Perley. The present status of the white pine blights. U. S. Dept. Agr. Bur. Pl. Ind. Cir. 35: 1–12. August 1909.

[32] Stevens, F. L. and Hall, J. G. Diseases of economic plants. pp. 445–446. 1910.

showed diseased leaves still attached to the lower more healthy part. The bark in the diseased region was slightly swollen and exhibited a peculiar granular appearance, chiefly caused by what looked to the naked eye like an abnormal lenticel development. Cross sections through this diseased part revealed the presence of mycelium, but whether or not this belonged to the *Lophodermium brachysporum*, could not be definitely determined.

Although the two places in North Carolina above mentioned were the only stations where the disease was observed in the southern Appalachians, the amount of damage done was considerable, especially on the young four or five year old plantation near Highlands.

In connection with the *Lophodermium brachysporum* associated with the leaf blight there commonly occurred a form which appeared to agree with the description and exsiccati of another fungus: i.e., *Hypoderma lineare* Peck (figs. 9 and 10). This may, however, be nothing but an abnormally developed form of *Lophodermium brachysporum*. The writer bases this belief on the following considerations:

1. Cross sections showed the fruiting body to be essentially the same in structure, and in location between epidermis and hypodermis of the leaf, as in *L. brachysporum*.

2. The fruiting bodies were uniformly abortive, i.e., contained no asci.

3. The fruiting bodies, although in general linear in outline, exhibited a more or less irregular and variable margin, exterior surface and opening, (fig. 9), as if developed in an abnormal way.

4. The fruiting bodies sometimes occurred on the same leaf with the normal fruiting bodies of *L. brachysporum*, with apparently gradual transitions into the normal form (fig. 10).

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## REVIEW

Studies of fungous parasites belonging to the genus Glomerella. Shear, C. L. and Wood, Anna K. U. S. Department of Agriculture, Bureau of Plant Industry, Bulletin 252, 110 pages, 18 plates, 1913.

The primary object of the investigation has been to determine the life histories and the relationships of the forms of Gloeosporium and Colletotrichum found upon the same hosts or on different ones. Some hundreds of species of these fungi have been described, but a critical monograph of either of the genera has never been published. The species have hitherto been based upon slight differences in spore characters, the appearance of the part affected, occurrence upon different hosts or even on different parts of the same host.

The writers base their systematic work upon the following premises: where no fairly constant morphological characters separate the forms growing upon different parts of the same host, these forms should be referred to the same species; where the forms occur on different hosts, but still show no reasonably constant characters for their separation, they should also be regarded as one species. Their separation even as so-called "physiological species" must depend upon a sufficient number of successful cross inoculations which show the fungi will not pass from one host to another.

In the present publication the results of studies of forms from 45 different hosts are given. These investigations began in 1904 and have continued to date. They have included pure culture work with each form; pedigree, pure-line, single-spore cultures with both conidia and ascospores for many generations; morphological studies; physiological studies of the effect of different media, temperature, etc., upon the production of ascospores, and other variations of the fungi; and transfers from host to host. No cytological work has been done.

It was found that the variability of the same fungus from the same host is so great that no character, either morphological or physiological, seems to be well fixed, and many forms intergrade so intimately that there is no specific difference to be found. The perfect stages of the forms from 36 of the hosts have been obtained, a considerable number being here reported for the first time.

The 36 forms from as many different hosts have been reduced to 3 species: *Glomerella cingulata* (Stonem.) S. & v. S., *G. gossypii* Edge. and *G. lindemuthianum* Shear n. comb.

The two latter are apparently quite distinct and are limited in their host plants. The first includes the great mass of fruit- and leaf-inhabiting

forms which were investigated, including the well known apple bitter rot fungus.

It was found that apparently healthy leaves of many different plants in the greenhouse developed the fungus when the exterior was sterilized with corrosive sublimate and the leaves placed in sterilized moist chambers. Great variation was found in the production of asci; when cultures were made from the same leaf or fruit, sometimes one ascus produced only conidia, while another produced asci. There are apparently very distinct ascus-producing strains of the same fungus which will transmit this ability through a long series of generations. In no case was a "conidial" strain found to later develop asci in pure cultures, nor were there any evidences of sexual union between strains, such as Blakeslee demonstrated for Mucor.

The extensive cross inoculation experiments between hosts show the extreme readiness of these fungi to attack the most varied host species. It was found that strains of the fungus from the same host vary in virility.

The reviewer's experience with the apple bitter rot fungus some years ago, when pure cultures of the fungus were successfully inoculated onto such diverse hosts as pear, squash and Crataegus fruits leads him to believe that the writers have adopted the only course open in revising these species. Their publication bears evidence of the great amount of careful and painstaking labor done in these investigations. The absence of any evidence of the permanent change of any single character beyond its usual variations is significant, as it would seem that such an occurrence might take place in a group of this kind if at all. On the other hand, distinct variations were secured in the pedigree, single-spore, pure-line cultures; however these did not persist but soon disappeared. This is believed by the authors to show that they should be considered as fluctuating variations rather than what are usually called mutations.

The writers conclude that the production of asci is a hereditary racial character which is not dependent primarily upon special conditions of nutriment or environment. The large amount of data, which has been accumulated by numerous investigators since Atkinson first demonstrated the existence of an ascogenous stage for a Gloeosporium, has been critically reviewed and utilized. Where the writers' results differ from those of previous investigators, that fact is plainly stated. A list of about 10 papers and 18 plates, which are indispensable to a good understanding of the text, close the bulletin. It is not too much to say that the bulletin is full of suggestions to all who have to do with the investigation of fungous parasites. It makes a distinct advance in our knowledge of the evolution of new races of fungi and clears the field of a number of erroneous theories regarding it. The caution with which general conclusions have been drawn is not the least commendable feature of the publication.

PERLEY SPAULDING.

## PHYTOPATHOLOGICAL NOTES

*Destructive effects of Trametes pini and Echinodontium tinctorum.* In the living tree a heartwood destroying fungus seldom extends its activities beyond the main body of the trunk. In this connection some very interesting variations have been observed by the writer in the case of *Trametes pini* and *Echinodontium tinctorum*. The former fungus after decomposing the greater part of the heartwood of living western red cedar has been found to extend its ravages into the limbs and smaller branches of the tree. Every branch in one critically examined specimen down to a diameter of 1 inch or less was found to have the heartwood destroyed by the fungus, even the smaller lateral limbs of the main infected branch being attacked. *Trametes pini* is very common on the western red cedar but is not the cause of the universal heart rot of this species.

A condition similar to that noted above has been observed for *Echinodontium tinctorum* in western hemlock and grand fir. Bell shaped sporophores of this fungus have been collected on branches of living trees, 5 to 8 feet out from the main trunk. The smaller lateral branches were likewise attacked.

These points are of interest in as much as they illustrate the unparalleled activity of some wood rotting fungi in the heavily infected forests of the northwest.

JAMES R. WEIR.

*Personals.* Dr. Harry B. Humphrey, recently Professor of Botany in the State College at Pullman, Washington, was appointed Pathologist in the office of Grain Investigations of the Bureau of Plant Industry, U.S. Department of Agriculture, March 1, 1913. Dr. Freda M. Bachmann, last year assistant in botany and plant pathology, University of Wisconsin, is now at Milwaukee-Downer College in charge of the work in botany and bacteriology.

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